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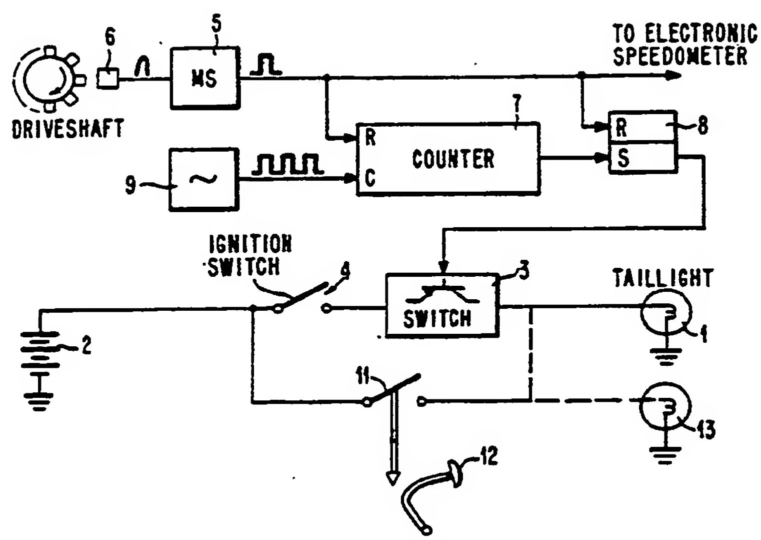

(57) Abstract

Intelligent electronic circuit apparatus is disclosed for automatically controlling the hazard warning system (such as a tail light (1)) of a motor vehicle so as to assist in preventing accidents. The apparatus includes a switch (3) for selectively connecting the tail light with a voltage source (2) and a control device for automatically closing the switch, thereby connecting the tail light to the voltage source, in response to a condition indicating a hazard to other vehicles in the vicinity. The invention provides means for sensing the driving environment of the motor vehicle and for changing the condition of response in dependence upon the sensed environment.

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INTELLIGENT, AUTOMATIC HAZARD WARNING SYSTEM FOR A MOTOR VEHICLE

BACKGROUND OF THE INVENTION

The present invention relates to the field of motor vehicles and, more particularly, to an electronic collision avoidance system for a motor vehicle which aids in avoiding motor vehicle accidents.

Frequently, a motorist experiences a traffic situation of the following nature: The vehicle which the motorist is driving - call it "Vehicle 2" - is proceeding down a highway at a normal highway speed - say, 30-65 mph - while the vehicle of another motorist - call it "Vehicle 1" - is stopped or proceeding considerably slower on the same highway ahead of Vehicle 2. There may be any number of reasons why Vehicle 1 has stopped or proceeds slowly: The operator of Vehicle 1 may intend to turn left after oncoming cars have passed; there may be traffic congestion ahead of Vehicle 1; Vehicle 1 may be proceeding slowly because the road is upwardly inclined; Vehicle 1 may have stopped or may be proceeding slowly because the operator of Vehicle 1 is looking at something along the road; or Vehicle 1 may be disabled with an overheated engine, flat tire or the like. Sometimes the operator of Vehicle 1 will have applied the brakes, so that the brake lights of Vehicle 1 are illuminated, alerting the operator in Vehicle 2. Quite often, however, the operator of Vehicle 1 does not have a need to apply the brakes because Vehicle 1 has already stopped, is proceeding slowly at a steady speed, or is

even accelerating. The operator of Vehicle 1 can switch on flashing "hazard" lights, but this requires positive action on the operator's part which is frequently forgotten. In the absence of any warning lights (brake lights or hazard lights) or some other warning indication from Vehicle 1, the operator of Vehicle 2 may not notice that Vehicle 1 has stopped or is proceeding slowly until it is too late to prevent Vehicle 2 from colliding with the rear of Vehicle 1.

There are numerous other situations in which it would be desirable and helpful if a first vehicle (Vehicle 1) were able to automatically warn the operator - driver of a second vehicle (Vehicle 2), which is behind the first vehicle and proceeding in sustantially the same direction, of an increased danger of a collision. For example, the operator of the first vehicle may wish to warn the driver of the second vehicle that the second vehicle is tailgating the first vehicle, or that the closing speed of the second vehicle with respect to the first vehicle is excessively high.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide means for automatically controlling a tail light of a motor vehicle in such a way as to alert drivers behind this vehicle and within sight of such tail light that there is an increased danger of collision with this vehicle.

It is a further object of the present invention to provide means for automatically transmitting a signal from a first (own) motor vehicle to a second (other) motor vehicle so as to alert the driver of the second motor vehicle of an increased danger of collision with the first motor vehicle.

These objects, as well as other objects which will become apparent from the discussion that follows, are achieved, according to the present invention, by providing a system that automatically switches on a warning tail light of a motor vehicle (such as the hazard lights) and/or transmits a warning signal when the motor vehicle operator fails to do so and for substantially the same reasons that would lead a vehicle operator to manually switch on the existing hazard lights; in particular:

(1) when the motor vehicle speed (instantaneous or average speed) falls below a prescribed threshold speed for a prescribed period of time;

(2) when the instantaneous motor vehicle speed falls below the time average vehicle speed by a prescribed amount for a prescribed period of time;

(3) when the closure speed between the motor vehicle and another motor vehicle, either in front or in the rear, exceeds a

prescribed value;

(4) when the distance between the motor vehicle and another motor vehicle, either in front or in the rear, falls below a prescribed value;

(5) when one road wheel of the motor vehicle does not rotate at substantially the same speed as another road wheel or the other road wheels of the vehicle (thus indicating wheel spinning, skidding or brake lock);

(6) when the motor vehicle is mechanically disabled for any reason; and/or

(7) when a warning signal, transmitted from a vehicle ahead, is recieved.

Such a system can be easily and inexpensively realized by providing, in a first embodiment: (a) a light switch between a source of voltage and a tail light, and (b) a switch control circuit, coupled to this switch, for closing the switch, thereby automatically connecting the tail light with the voltage source, when (either immediately, or some prescribed delay time after) some event occurs, indicating the necessity or desirability of switching on the tail light.

Such a system may also be realized, in a second embodiment, by providing: (a) a low power RF transmitter, and (b) a control circuit and switch for keying the transmitter to transmit an RF signal when some event occurs, indicating the necessity or desirability of warning nearby vehicles of the danger of collision.

It is contemplated that the light switch in the first embodiment will turn on the conventional flashing hazard lights

of a motor vehicle. In the alternative, the switch can operate a special warning light visible from the rear, such as a rotating beacon, or even the conventional tail lights of a motor vehicle in any other manner so as to warn all vehicles approaching from the rear.

As used herein, the term "prescribed", as in "prescribed threshold speed" and "prescribed period of time", merely means "particular", "distinct", or "given". It is not intended that this term be limiting in any way and, specifically, it is not used in the sense of "fixed" or "preset". All "prescribed" parameters which are used in the system according to the invention to control the switch that turns on a tail (hazard) light of a motor vehicle, or key an RF warning transmitter, may have any value, from zero to any desired number, and may be:

(1) preset at the factory when the system is manufactured;

(2) adjustable by the operator of the motor vehicle (e.g. by a knob or the like on the dashboard or steering column); and/or

(3) automatically adjustable in response to other parameters.

The prescribed speed threshold, below which a tail light of the motor vehicle is automatically switched on and/or the RF transmitter is keyed in certain embodiments of the invention, is preferably in the range of 0-40 mph. For example, the prescribed speed may be approximately 15 mph, a relatively slow speed compared to normal highway speeds of 30-65 mph. Alternatively or additionally, the prescribed speed threshold may be much slower; for example, in the range of 0-5 mph. This will ensure that the

tail light is switched on only when the vehicle is stopped, stalled or disabled.

Similarly, the "prescribed period of time" may be anywhere in the range of 0 to 60 seconds. A ten second period would appear appropriate and convenient for most applications.

It will be understood that each condition described above – for example, when the instantaneous or average speed of the vehicle falls below a prescribed speed for a prescribed period of time – may be only one of a number of conditions, all of which must be (AND function), or any of which may be (OR function), present to cause the hazard warning system to be automatically switched on. Thus, according to a preferred embodiment of the present invention, a number of conditions may be combined, as follows:

(1) In order to avoid the illumination of the tail light or the continuous transmission of a warning signal when the vehicle is parked, it is preferable that the tail light be automatically switched on, or the RF transmitter keyed, only when the ignition switch of the vehicle is also switched on. This may be accomplished by connecting the light switch or control switch, provided according to the present invention, in series with the ignition switch. As used herein, the term "ignition switch" is intended to refer to the switch that controls the power to the engine ignition system, to the switch that is activated by the presence of the ignition key in the key slot, and/or to any other switch which indicates the presence of the motor vehicle operator within the vehicle and/or his intention to operate the vehicle.

(2) In order to avoid the illumination of the tail light,

or the transmission of a warning signal, when the vehicle is briefly brought to a halt at a traffic light, stop sign, toll booth or other normal traffic interruption, it is preferable that the tail light be switched on, or the RF transmitter keyed, only after a period of time has elapsed since the speed of the vehicle falls below, and remains below, the aforementioned prescribed speed. This time period, which may be in the range of 30 seconds to two minutes, for example, may be adjusted by the operator or automatically adjusted in accordance with driving conditions. For example, if the vehicle has been driving in stop-and-go city traffic, the adjustment may be different than if it has been driving for lengthy periods at high speed along major thoroughfares or superhighways. According to a particular feature of the present invention, a microprocessor program keeps track of the recent driving "history" of the vehicle and automatically makes suitable adjustments to the controlling conditions indicative of a hazard in dependence upon the driving environment.

(3) In order to avoid the illumination of the tail light, or transmission of a warning signal, whenever the ignition switch is turned on to start the vehicle engine, it is preferable that the tail light be switched on, or the RF transmitter keyed, only if the vehicle engine is running. Substantially the same effect can be accomplished by connecting a timer to the ignition switch and permitting the tail light to be switched on, or the RF transmitter keyed, only when a prescribed length of time has elapsed after the ignition switch is turned on. This time may be

in the range of 1-2 minutes, for example.

(4) At the expense of some additional hardware such as a police or Rashid VRSS radar system which detects the closing speed and distance of approaching vehicles, it is advantageous if the tail light be switched on if a second motor vehicle approaches the first vehicle from behind, or the first vehicle approaches the rear of the second vehicle, with a closing speed - i.e., with a difference in speeds between the two vehicles - which exceeds a prescribed value, and/or with a distance between the two vehicles that falls below a prescribed value. The requirement that a plurality of such conditions exist before automatically switching on a tail light or transmitting a warning reduces the possibility that a hazard warning will be given at unnecessary and inappropriate times.

When a motor vehicle provided with a hazard warning system according to the present invention is involved in a traffic situation of the type described above in the "Background of the Invention" section, it will indicate to motorists behind it that it is either proceeding very slowly down the highway or has stopped completely, whether or not the operator of this vehicle has applied the brakes or has manually turned on the hazard lights.

If the system according to the present invention should automatically switch on a tail light of the vehicle, or transmit a warning signal, thus indicating a hazard, when in fact there is no hazard, the operator of the motor vehicle may switch off the hazard warning system by operation of an override switch. For example, such switching <u>off</u> of an automatically switched on tail

light, requiring positive action on the part of the motor vehicle operator, is preferable to systems, presently known in the art, which require the vehicle operator to take positive action to switch the hazard lights on.

In a particular, advantageous embodiment of the present invention, the device for controlling the tail light switch operates to turn the switch on and off at a rate which is dependent upon the speed of the vehicle. In this way, motorists behind the vehicle may observe at a glance the speed with which this vehicle is traveling.

It will be understood that the "tail light" of a motor vehicle, as this term is used herein, may be any one of the lights arranged at the rear of the vehicle for signaling motorists behind it. For example, the tail light may be the red brake lights of the motor vehicle; it may be the amber turn signal lights; it may be the white back-up lights or it may even be an additional light of the same or another color which is mounted on the top or rear of the motor vehicle. An example of the latter type of "tail light" would be a rotating beacon arranged in the rear window of a motor vehicle.

Similarly, it will be understood that the "RF transmitter" of a motor vehicle, as this term is used herein, is intended to mean an RF transmitter of any type which transmits a warning signal to nearby vehicles. Since the principal purpose of this transmitter is to communicate with vehicles toward the rear which are not within line of sight of the transmitting vehicle, so that the drivers of such vehicles cannot see the tail lights of the

transmitting vehicle, it is preferable that the frequency of transmission be sufficiently low that obstructions in the line of sight, such as bends in the road or other vehicles, do not affect the signal reception. It is contemplated that the transmitted carrier signal be modulated by coded information indicating the type of hazard and/or the reason why the warning signal is being transmitted. For example, if the transmitting vehicle is disabled, the transmitted signal can alert the police or other assistance by means of an encoded "SOS" or "HELP" message.

Finally, as an added feature of the present invention, the device for controlling the flashing hazard lights and/or the RF transmitter may also be made responsive to the burglar alarm system of the the motor vehicle so that, if the vehicle is driven by any unauthorized person, the hazard lights will flash and/or the RF transmitter will transmit a coded signal. In this way, the motor vehicle will continuously be "tagged" as a stolen vehicle.

In addition, or in the alternative, the device may be made responsive to the operation of the engine without insertion of an ignition key, so as to activate the hazard lights or the RF transmitter whenever the engine is started by "jumping" the ignition wires.

For a full understanding of the present invention, reference should now be made to the following detailed description of the preferred embodiments of the invention and to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram of an electrical circuit according to one preferred embodiment of the present invention for controlling the tail light of a motor vehicle.

Fig. 2 is a block diagram of another preferred embodiment of the present invention.

Fig. 3 is a graph of time versus speed, illustrating the operation of the embodiment of Fig. 2.

Fig. 4 is a block diagram of still another preferred embodiment of the present invention which includes a microprocessor.

Fig. 5 is a flow chart of a program which may be used with the microprocessor in the embodiment of Fig. 4.

Fig. 6 is a diagram showing a second vehicle V2 traveling behind a first vehicle V1 at a greater speed S2 than the speed of the first vehicle S1.

Fig. 7 is a block diagram of still another preferred embodiment of the present invention.

Fig. 8 is a diagram, similar to Fig. 6, showing a second vehicle V2 traveling in front of a first vehicle V1 with a slower speed S2 than the speed of the first vehicle S1.

Fig. 9 is a diagram of a dashboard display for a collision avoidance system according to a preferred embodiment of the present invention.

Fig. 10 is a block diagram, similar to that of Fig. 4, showing still another preferred embodiment of the present invention.

Fig 11 is a schematic diagram of the wiring of a motor

vehicle in accordance with still another preferred embodiment of the present invention.

Figs 12a and 12b, taken together, are a block diagram of still another preferred embodiment, according to the invention, for automatically switching on the hazard warning system of a motor vehicle.

Figs. 13a, 13b and 13c, taken together, are a flow chart of a software program, according to the invention, for use with the embodiment of Fig 12.

Fig. 14 is a flow chart of a brief subroutine called in the program of Fig. 13.

Fig. 15 is an exemplary diagram of a speed histogram of a motor vehicle.

Fig. 16 is a representational diagram showing the major inputs and outputs to a motor vehicle collision avoidance system according to the present invention.

Fig. 17 is an elevational view of the front faceplate of the collision avoidance system of Fig. 16.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention will now be described with reference to Figs. 1 - 17 of the drawings.

Fig. 1 illustrates a motor vehicle tail light 1 which is connected to a source of voltage 2 - i.e., the motor vehicle battery - via an electronic power switch 3 and an ignition switch 4.

The electronic switch is turned on (i.e., "closed") by means of an electronic control circuit when the speed of the motor vehicle falls below a prescribed threshold, such as 15 mph. The tail light remains off when the vehicle is stopped and the ignition switch is turned off.

The control circuit comprises a monostable multivibrator 5 which receives electrical pulses from a drive shaft rotation sensor 6. Pulses produced by the monostable MV 5 are supplied to the electronic speedometer and odometer of the motor vehicle. These pulses are also applied, as reset pulses, to a counter 7 and a flip-flop 8. Clock pulses are supplied to the counter by an oscillator 9.

The counter 7 produces a carry pulse on its output carry line 10 whenever the counter has reached its maximum count. This situation will occur unless the counter is reset before reaching its maximum count by a pulse from the monostable MV 5. The carry pulse produced by the counter 7 sets the flip-flop 8 which, in turn, supplies a control signal that turns on the switch 3.

The flip-flop 8 is reset each time a pulse is received from the monostable MV 5. If the vehicle is proceeding slowly, this

flip-flip 8 will be set again shortly thereafter by the carry pulse from the counter 7. It will be understood that the rate at which the flip-flop 8 is reset is directly dependent upon the speed of the motor vehicle. This causes the switch 3 and, thus, the tail light 1 to be turned on and off at a rate which is dependent upon the speed of the vehicle. If the vehicle speed exceeds the prescribed threshold, the counter will be unable to produce a carry pulse and the switch 3 and tail light 1 will remain off.

Also shown in the figure is a mechanical switch 11 that is operated by the vehicle brake pedal 12. This switch 11 is normally incorporated into the hydraulic brake cylinder of the motor vehicle. The brake switch 11 can be connected in parallel with the electronic switch 3 to operate the tail light 1, or it may be connected to a separate tail light 13 in the manner shown in dashed lines.

Fig. 2 illustrates a modification of the circuit of Fig. 1 wherein the switch 3 is turned on, thus illuminating the tail light 1, whenever the instantaneous speed of the vehicle drops abruptly. This arrangement would cause the tail light to be illuminated, for example, when the vehicle is brought to a standstill on a highway. The tail light 1 would not be illuminated when the vehicle is initially started in a parking lot or a garage.

Pulses from the monostable MV 5 are applied to two digital circuits: a first circuit 14 which integrates these pulses once to determine the instantaneous speed, and a second circuit 15 which integrates these pulses twice to determine the time average

speed of the vehicle. Digital signals representing the instantaneous speed and time average speed, respectively, are applied to a subtractor 16 which produces an output on parallel lines 17 representative of the difference between the time average speed and instantaneous speed. If this difference is negative - that is, if the instantaneous speed is less than the time average speed - with an absolute value in excess of a prescribed threshold, a threshold circuit device 18 produces an output signal which turns on the switch 3.

The instantaneous speed, determined by the circuit 14 may be displayed by a speedometer/display device 19. This speed may also be applied to a flash control circuit 20 which operates an electronic switch 21 in the circuit between the threshold device 18 and the switch 3. The flash control device 20 functions to turn the switch 3 on and off at a rate which is dependent upon the speed of the vehicle.

Fig. 3 illustrates the operation of the circuit of Fig. 2. In Fig. 3, the curve 20 represents the instantaneous speed S of vehicle whereas the darker curve 21 represents the time average speed S_{ave}; namely, the instantaneous speed S integrated over a period of time, such as the previous minute. The integral may be divided by this period of time, or by some other constant K, to give the average.

$$S_{ave} = \frac{\int S \, dt}{60 \text{ sec.}} \over K$$

As is shown, the vehicle speed starts at zero at time t_0,

increases to a plateau (the normal driving speed) and then falls off to zero again. The average speed follows the instantaneous speed with some delay. At time t_1, the difference between the instantaneous speed and the average speed is a negative value which exceeds a prescribed threshold. At this time the tail light 1 is caused to turn on. Sometime later, at time t_2, the average speed "catches up" with the instantaneous speed so that the difference between these two values falls below the prescribed threshold and the tail light 1 is turned off.

Fig. 4 shows still another embodiment of the circuit according to the invention for automatically controlling a tail light of a motor vehicle. A drive shaft rotation sensor 30 produces pulses which are integrated by a circuit 32 to provide an analog speed signal S. An A/D converter 34 supplies this signal S, in digital form, to a first input I_1 of a microprocessor 36. The microprocessor receives at a second input I_2 a "1" or "0" signal in dependence upon the position of the vehicle "ignition switch" 38. As indicated above, this switch may be the switch that controls the power to the vehicle ignition system, the switch indicating the presence or absence of the ignition key in its slot, or some other relevant switch that indicates that the associated motor vehicle is being operated.

The microprocessor 36 operates on the signals presented at the inputs I_1 and I_2 and produces a signal on its output line 40 which resets a timer switch 42 to its initial state. When the timer 42 receives such a reset pulse, it switches on the power to the motor vehicle tail light 44. Preferably, the tail light is

provided with a flasher, so that it will blink in the manner of conventional motor vehicle "hazard lights". The timer 42 remains switched on until it times out, for example after 10 seconds.

The microprocessor 36 is programmed in accordance with the algorithm or routine shown in Fig. 5. After the routine is entered at 50 it immediately obtains the current speed S from the input I_1 (block 52). If this speed is equal to or greater than the prescribed threshold speed T_1 (e.g., 15 mph) at block 54 then a flag is reset to "off" at block 56 (if it is not already off) and the routine returns to the beginning. If the speed S is less than the threshold speed T_1, then the program determines whether or not the flag is on (block 58). If the flag was off, then the flag is set to "on" and a parameter t is set equal to zero (block 60). If the flag was "on" at block 58, then the parameter t is incremented by one (block 62).

The parameter t is then tested at block 64 to determine whether it has exceeded a second threshold T_2. The purpose of this test is to take action, to cause the tail light to switch on, only after the speed S has remained below the prescribed threshold T_1 for a prescribed length of time. If the parameter t has not yet reached the threshold T_2, the routine starts again from the beginning; if it has, then the program tests to determine whether the ignition switch is on (block 66). If it is not, the program returns to the beginning; if it is on, then the microprocessor produces a pulse at its output 40 to reset the timer switch 42 (block 68).

Fig. 6 illustrates how a first vehicle V1 may determine the closing speed of a second vehicle V2. In this case, the vehicle

V1 is provided with a conventional police radar system, having an antenna 70 pointed toward the rear, for measuring the closing speed of an oncoming vehicle V2. If the vehicle V1 were stationary, then the radar would exactly determine the absolute speed S_2 of the vehicle V2. If the vehicle V1 is in motion with a speed S_1, then the radar determines the difference between the speeds of the vehicles V1 and V2; that is, the difference $S_2 - S_1$. According to the invention, this difference $S_2 - S_1$ is used as one of the conditions for automatically switching on the tail lights (hazard lights) of the vehicle V1. In particular, if the difference $S_2 - S_1$ exceeds a prescribed threshold, then the vehicle V1 is in danger of being struck by the vehicle V2 and the hazard lights of the vehicle V1 are switched on.

Instead of a police radar system, it is, of course, also possible to use a Rashid VRSS collision warning system, or any other system which is capable of determining the presence and/or relative speed of another vehicle from a first vehicle. For example, it is desirable to automatically turn on the tail light of a motor vehicle if another vehicle behind it comes too close. In this case, a proximity warning system may be used to detect the presence and distance of a second vehicle with respect to an own vehicle, provided only that the second vehicle is in the same driving lane as the own vehicle. If the second vehicle comes closer than a prescribed distance - say, the distance equal to the speed of the own vehicle divided by ten and multiplied by the length of a standard motor vehicle - then the system according to the present invention automatically turns on a tail light of the

own, first vehicle to prevent "tailgating" by the second vehicle behind it.

Fig. 7 illustrates still another embodiment of the present invention whereby a vehicle tail light 100 and flasher 102 are switched on upon the simultaneous occurence of a number of conditions represented by the blocks 104-116. The outputs of these blocks are supplied to an AND gate 120 which closes a switch 122 if and only if all of the blocks 104-116 produce an output.

After the switch 122 has been closed, thereby switching on the flashing tail light 100, the circuit may be interrupted by the motor vehicle operator, thereby switching off tail light 100, by means of a manual override switch 124.

The conditions for switching on the tail light, represented by blocks 104-116, are as follows:

(1) In block 110, the absolute speed S_1 of the vehicle falls below a prescribed threshold T_1.

(2) In block 108, the coolant temperature T of the motor vehicle engine exceeds a prescribed threshold T_2.

(3) In block 104, the ignition switch of the motor vehicle is turned on.

(4) In block 106, the ignition switch 104 has been turned on for a prescribed length of time T_3.

(5) In block 112, the vehicle speed S_1 has fallen below the prescribed threshold T_1 for a prescribed length of time T_4.

(6) In block 114, the difference in speeds $S_2 - S_1$ between vehicles V2 and V1 exceeds a prescribed threshold T_5.

(6) In block 116, the difference between the instantaneous speed S_1 and the time average speed, S_1 dt, exceeds a prescribed

value T_6.

It will be appreciated that less than all of the above mentioned conditions may be used to close the switch 122 to thereby switch on the tail light 100. It will also be understood that further conditions, in addition to or in place of those described above, may be used to automatically determine when the switch 122 is to be closed.

Fig. 8 illustrates, in a manner similar to Fig. 6, a radar system 70 for detecting the presence, speed and/or closing speed of a second vehicle V2 with respect to an own vehicle V1 behind the second vehicle. In this case, the radar system 70 is mounted on the front of the own vehicle V1 for monitoring possible collisions in the front. The radar system (which may be a police rader, a Rashid VRSS collision warning system or any other similar device) produces a warning signal to alert the driver of the own vehicle of the possibility of a collision. This warning signal is preferably the result of a determination which takes into account both the closing speed and distance of any adjacent vehicle either in front of or behind the own vehicle. The closer the distance between the own vehicle and an adjacent vehicle in front or behind, the lower will be the threshold value of closing speed above which a warning signal is produced and an audible and visible alarm is given.

According to the invention, this warning signal is also used to automatically turn on the tail light of the own vehicle to warn the operators of vehicles behind it that the own vehicle may soon slow down or stop abruptly. This "hazard warning" is

helpful to prevent "chain reaction" type accidents, where a lead vehicle in a chain collides with a vehicle in front of it, or otherwise stops too abruptly for the vehicle behind, and there is a second collision, and then a third, and so forth.

Fig. 8 further illustrates a tachometer generator 72, 74 or speed measuring device connected to each wheel of the own vehicle V1. The speeds of the front and rear wheels on each side of the vehicle are compared in a comparator 76 and a signal is generated by a threshold circuit (Schmitt trigger) 78 if the difference in speed exceeds a prescribed limit. The output on line 80 generated by the threshold circuit is used to turn on the hazard warning tail lights of the own vehicle V1, as an indication that one or more of the wheels of the vehicle V1 have been "blocked" or locked on braking. There is, of course, an identical circuit for the wheels on the opposite side of the vehicle.

As shown in Fig 8, the own vehicle V1 is proceeding at a faster speed S1 than is the second vehicle V2, which is traveling at a speed S2, thus creating a possibility of collision.

Fig. 9 shows still another embodiment of the present invention wherein a microprocessor 130 monitors a plurality of inputs I1, I2, I3, I4, I5, I6, I7, I8 and I9 and bumps a timer switch, in the manner described above in connection with Fig. 4, when the ignition switch is turned on (a signal is present at input I2), and one or more of the following events occur:

(1) The motor vehicle speed received at input I1 (or the time average of this speed as calculated by the microprocessor) drops below a prescribed threshold speed for a prescribed period

of time (as described above in connection with Fig. 5).

(2) The closing speed with respect to a vehicle to the rear (input I3) or a vehicle to the front (input I4) of the own vehicle exceeds a prescribed value (which may be dependent upon the distance to the respective vehicle to the rear or in front).

(3) The distance between the own vehicle and a vehicle to the rear (input I5) or a vehicle to the front (input I6) falls below a prescribed value.

Both the prescribed value of the closing speed (paragraph 2, above) or the distance (paragraph 3, above) may be automatically selected by the microprocessor in accordance with the driving circumstances, or varied manually by the vehicle operator. For example, the prescribed value of distance may be automatically increased with increasing speed of the own vehicle in accordance with the formula:

S/10 times 12,

where S is the vehicle speed (presented at input I1) and 12 is the approximate length (in feet) of a typical vehicle.

The microprocessor may be provided with any number of other inputs I7 which call for switching on the hazard lights when a signal is present. For example, the input I7 may be connected to the output of the AND gate 120 (Fig. 7) or to the threshold gate 78 (Fig. 8), or both.

The microprocessor is provided with two yet additional inputs I8 and I9 which receive digital signals representing manually selected prescribed values. Such prescribed values may be selected by the vehicle operator using a control panel of the

type illustrated in Fig. 10.

Fig. 10 shows a control panel 140 which receives the inputs I3, I4, I5 and I6 from the radar system and produces the microprocessor inputs I8 and I9. The digital signals presented by the inputs I3, I4, I5 and I6 are merely displayed by suitable digital displays 142 and 144. The closing speed and distance of a vehicle to the front and to the rear of the own vehicle may be time-shared on two displays as shown.

Knobs 146 and 148 are provided to permit manual selection of the prescribed speed (T1) and prescribed time (T2) which are used by the microprocessor to determine when to automatically switch on the hazard lights. The settings of these knobs are displayed on a single time-shared digital display 150. The operator of the motor vehicle may thus select the speed and/or time delay at which a tail light (warning or hazard light) is activated.

Fig. 11 shows a portion of a wiring diagram of a motor vehicle comprising four wheels 160, a battery 162 and a pair of tail lights 164 connected to the battery via a relay switch 166. A control device 168 closes the normally open switch 166 when one or more of a number of conditions occur which indicate an increased danger of collision.

The control device receives a signal on line 170 from an ignition switch 172 indicating whether an ignition key has been inserted in the key slot. The control device also receives a signal on line 174 indicating whether the starter relay 176 has been activated (closed) to provide voltage to the engine starter 178. The control device measures the time during which an attempt is made to start the vehicle engine and turns the tail

lights 164 on and off in a flashing mode, to provide a hazard warning to others, when the measured time exceeds a time period threshold. The control device 168 also flashes the tail lights when a number of other conditions occur, indicating that the vehicle is mechanically disabled. As shown by the inputs 180, the control device actuates the switch 166 when the engine temperature exceeds a safe value, when the engine hood is opened, when a vehicle door is opened with the ignition key in the slot, and when a tire is flat or removed from the vehicle. Other common conditions indicating that the vehicle is mechanically disabled will occur to those skilled in the art.

As described above in connection with Fig. 8, the control device actuates the switch 166 when either front road wheel 160 rotates at a substantially different speed from a corresponding rear road wheel. The respective signal, indicating that a wheel is spinning or is brake locked, is supplied on line 182 from an OR gate 184. This OR gate receives the signal from one of the two lines 80 and threshold gates 78 when the speed difference between a front an a rear wheel exceeds a prescribed threshold.

In addition to turning on the hazard lights and/or transmitting a warning signal, the collision avoidance system according to the present invention may be made operative to:

(1) warn the vehicle driver by sounding an audible warning (such as beeps or a synthesized voice);

(2) warn the vehicle driver by displaying a legend, such as "WATCH AHEAD" or "WATCH BEHIND"; and/or

(3) switch off the vehicle cruise control system.

In addition, the system according to the invention may be provided with "intelligence" so that it is capable of sensing and "adapting" to the particular driving environment of the motor vehicle and changing the conditions under which it switches on the tail lights and keys a warning transmitter. This intelligence thus prevents the system from initiating a hazard warning in situations where it is unnecessary and undesirable. For example, it is clearly not necessary (and, indeed, it is undesirable) to flash hazard lights in the stop-and-go city traffic environment. Such a system will now be described.

Figs. 12a and 12b (hereinafter "Fig. 12") illustrate a microprocessor controlled electronic system for controlling the hazard warning system (tail light, RF transmitter, audible warning and display) of a motor vehicle. This system includes a microprocessor 210 having a plurality of inputs 212 and a plurality of outputs 213. Connected to these inputs are five analog-to-digital converters 214, 215, 216, 217 and 218 which receive signals from five analog signal sources 220, 221, 222, 223 and 224, respectively. The signal source 220 indicates the actual measured speed of the motor vehicle. Signal sources 221 - 224 are manually adjustable potentiometers which permit manual entry of a threshold speed MS, a prescribed delay time MT and both forward and rearward minimum threshold distances to the nearest adjacent vehicle that is travelling in the same lane and in the same direction as the vehicle in which the system is installed. In addition, a warning receiver 225 is operative to receive RF warning transmissions from other vehicles and to supply the microprocessor 210 with either an interrupt signal or

a code indicative of the type of warning ("SOS", "go slow", etc.).

Signal sources represented by the blocks 226 - 255 on the left side of Fig. 12 provide on/off (logical "1" or "0") signals to the microprocessor 210 in dependence upon certain conditions or states of the motor vehicle. These conditions are:

Block 226: presence or absence of a key in the ignition switch;

Block 228: ignition switch on or off;

Block 230: brake pedal depressed or not;

Block 232: engine temperature exceeding, or not exceeding normal operating temperature;

Block 234: oil pressure normal or below normal;

Block 236: vehicle mechanically disabled in any other way (out of fuel, flat tire, etc.);

Block 238: vehicle hood, trunk and all doors are closed, or one of them is open;

Block 240: engine running or not running;

Block 242: parking brake on or off;

Block 244: clutch engaged or disengaged;

Block 246: transmission shifted into reverse or not;

Block 248: transmission shifted into a forward gear or not;

Block 250: manual speed control switched on or off;

Block 252: manual delay time control switched on or off;

Block 254: manual city driving control switched on or off;

Block 255: manual warning control switched on or off.

The microprocessor 210 receives these signals and operates

according to the program represented in the flow charts of Figs. 13a, 13b, 13c (hereinafter "Fig. 13") and Fig. 14. This microprocessor thus provides "intelligence" and selectively produces outputs on lines 213 which automatically turn on the hazard warning system of the motor vehicle. More particularly, the signal on line 256 is amplified by means of an amplifier 258 and supplied to a relay 260 to close the circuit between the vehicle 12 volt battery and an electric flasher 262. The flasher 262 periodically interrupts and then reconnects the voltage supplied to the motor vehicle tail lights 264. The automatically actuated switch 260 may be disabled by a manual switch 266 or bypassed by a manual switch 268.

Other outputs from the microprocessor 210 are line 257, connected through an amplifier to a loudspeaker 259; line 261 connected through an amplifier to a low power RF transmitter 263; line 265 connected to an intelligent alphanumeric character display (e.g. a twelve character display) 267; and line 269 connected through an amplifier to the cruise control system 271 of the motor vehicle. The microprocessor produces appropriate signals on these lines, at the appropriate times, to selectively activate the respective devices. In particular, the microprocessor repetitively provides a square wave signal at an audible frequency for brief (e.g., half second) periods on lines 257 and 271 to produce a "beep" tone in the loudspeaker 259 and to modulate an RF carrier frequency produced (upon receipt of the square wave) by the transmitter 263. The microprocessor also supplies ASCII code to the display device 267 on parallel lines 265 and provides a relay control signal to the cruise control

system 271 via the line 269 to switch off the cruise control.

Figs. 13 and 14 illustrate a software program which may be used with the microprocessor 210 to selectively activate the relay 260 (thus providing power to the light flasher 262), to provide beep signals to the loudspeaker 259, to key the warning transmitter 263, to provide ASCII code signals to the display 267 and to selectively deactivate the cruise control system 271, all in dependence upon the instantaneous state of the motor vehicle as well as the driving environment in which it finds itself. It will be understood that this program is only exemplary, and many other similar programs will occur to those skilled in the art to accomplish substantially the same purposes and objectives.

Since the flow charts of Figs. 13 and 14 are self-explanatory to a large extent, each of the various blocks in these charts will not be separately and individually described. However, some general commentary is desirable to set forth the objectives of the different sections of the program and to explain the exemplary techniques and methods used in the program to achieve these objectives.

The program is entered at block 270 and it immediately determines, in block 272, whether the ignition key of the motor vehicle is in the key slot (or an equivalent electronic key is on). If not, the timer variables T1, T2, T3 and T4 as well as the histogram used in the program are reset to zero and the program returns ("RT") to enter. If so, a number of parameters are tested to determine if the vehicle is in proper condition for operation.

The next major decision point is at block 274 which asks if the motor vehicle engine is running. If not, the program asks if the ignition switch has been turned on. If the operator has not turned the switch on (this being the reason that the engine is not running), a timer T1 is incremented for a relatively long period of time until it exceeds a preset threshold value A. After this time has elapsed, the microprocessor turns on the hazard warning system (flashes tail lights, warns driver by means of audible beeps or synthesized voice, warns other drivers by transmitting beeps or synthesized voice, turns off cruise control, etc.) as indicated by the letters "HW". If the engine is not running and the ignition switch is on, the engine may be disabled or the operator may have accidently left the key in the ignition with the switch on. In either case, a timer T2 is incremented for a relatively short period of time until it exceeds a preset threshold value B. After this short period has elapsed the microprocessor turns on the hazard warning system.

An exemplary procedure for turning on the hazard warning system is shown in Fig. 14. As is illustrated there, a timer T4 is repeatedly incremented until either the conditions cease which resulted in turning on the warning system, or the timer exceeds a preset threshold value C. In the latter case the hazard warning is automatically extinguished, it being assumed that the vehicle by this time has been moved or towed away. The threshold value C is set appropriately high so that the timer T4 may run for an hour or two before hazard warning system is switched off.

If the motor vehicle engine has been determined to be running, the program tests some additional parameters and takes

the appropriate action in response to the outcome. One such test is whether a warning signal has been received by the warning receiver 225 from another vehicle. If so, the driver is alerted by audible beeps or synthesized voice and the display 267 is provided with the characters "WATCH AHEAD". Another test, which is indicated in block 276, deserves detailed explanation.

During the operation of the program, the microprocessor is responsive to an interrupt signal from the brake pedal switch 230 (Fig.12) to update a count of the number (and/or length of time) of the actuations of the brake pedal by the vehicle operator during the preceding few minutes (e.g. 5 minutes). This value is then compared at block 276 to a preset threshold value D and, if this value is exceeded (indicating stop-and-go city driving), the program returns. If not, the program continues.

The program next tests to determine whether the vehicle operator has switched off the automatic "adaptive" speed control feature. If manual operation has been selected in block 278, the program reads in the manually selected speed MS from the potentiometer 222 and A/D converter 216. The actual measured speed S, read in from the sensor 220 and A/D converter 214, is then compared with the speed threshold MS and, if it exceeds this value, the program returns. If not, the program checks to determine whether the manual delay time switch has been turned on by the operator. If not, the hazard warning system is activated; if so, the program reads in the manually selected delay time MT from the potentiometer 224 and A/D converter 218 and compares the timer variable T3 with the threshold value MT. If the timer T3

has been incremented for a sufficiently long period of time so as to exceed the value MT, then the hazard warning system is activated. If not, the variable T3 is incremented and the program returns to the point where the speed S is compared with the threshold speed MS. In this way, if the speed S of the vehicle momentarily drops below the threshold speed MS, the hazard warning system will not be switched on unless the delay time threshold is set to zero (either manually or by switching off the manual delay time control).

Before proceeding to describe the portion of the program beginning with block 280, it is desirable to consider the vehicle speed histogram illustrated in Fig. 15. This histogram is a tabulation of the actual speed of the vehicle during a previous period, such as the previous ten minutes of driving. In the example shown, the vehicle drove at speeds of 5, 10 and 15 MPH for 1 1/4, 1 1/2 and 1 minute, respectively. The vehicle drove at 20, 25, 30 and 35 MPh for about 1/2 minute each. Most of the vehicle travel time during the previous 15 minutes was spent at higher speeds, however, as the graph shows. The vehicle travelled 1 minute at 40 MPH, 2 1/2 minutes at 45 MPH, 3 minutes at 50 MPH and 2 1/2 minutes at 55 MPH.

The resulting "histogram" has three maxima, at 10, 30 and 50 MPH, respectively, and two minima, at 20 and 35 MPH, respectively. The presence and magnitude of these various maxima and minima can be used to determine the current "driving environment" of the motor vehicle.

Considering once more the portion of the program illustrated in Fig. 13, in block 280 the program updates the histogram (adds

the current actual speed and deletes the oldest entry of speed) stored in memory. This updating funtion is therefore a "first in first out" amendment to the histogram so that the histogram always contains the most current speed data (data acquired during the last 10 minutes, for example). Thereafter, the program determines the maxima and minima in the histogram and sets the threshold speed TS equal to the highest minimum (e.g. 35 MPH in the example of Fig. 15).

The program then determines whether there is a maximum above 40 MPH. If so, it is assumed that the motor vehicle is operating on the open highway. If not, the program determines if the vehicle operator has manually set the switch 254 (Fig. 12) to city driving. If not, it is also assumed that the vehicle is operating on the open highway and the delay time DT is set equal to zero.

If the city driving switch has been manually set, or if the histogram has a maximum under 40 MPH and the actual, current vehicle speed S is under 40 (or some equivalent, medium speed), it is assumed that the vehicle is operating in a stop-and-go city environment. In this case the threshold delay time DT is set equal to about 1 minute (or such other time which is longer than the normal waiting period at a traffic light or in traffic). The program thus determines and "adapts" to the driving environment in which the motor vehicle finds itself.

Finally, the program at block 282 determines whether the parameter or parameters upon which the hazard warning decision is based have reached a condition or conditions, respectively, which

warrent activation of the hazard warning system. If desired, these conditions may also be varied in accordance with the driving environment. For example, the program at this point may determine whether the actual, instantaneous speed S of the vehicle is less than the threshold speed TS. If not, the program returns again to enter; but if so, the program then determines at block 284 whether the timer variable T3 has exceeded the threshold delay time DT. If not, then T3 is incremented and the vehicle speed S is again compared to the threshold speed TS to make sure that it is still below this threshold. If so, then the program turns on the hazard warning system. The value TS may be made high or low, in dependence upon highway or city driving conditions, respectively.

Other examples of hazard warning decisions which may be included (either alternatively or collectively) in block 282 are:

(1) Comparison of the average measured speed of the vehicle with a prescribed threshold (the average being taken either over a short time, such as 10 seconds, to reduce the effects of signal noise, or a longer time, such as 1 minute, to actually determine the average speed of the vehicle over such time) with a prescribed threshold;

(2) Comparison of the instantaneous, actual speed of the vehicle with the time average speed thereof;

(3) Comparison of the speed difference between the given vehicle and a second motor vehicle which is approaching the given vehicle either from the front or from the rear, with a prescribed threshold (either manually set or chosen automatically); and/or

(4) Comparison of the distance between the given vehicle and

a second motor vehicle, which is either ahead or behind the given vehicle, with a prescribed threshold (either manually set or chosen automatically).

Figs. 16 and 17 illustrate an actual implementation of the collision avoidance system according to the present invention. In this case, Fig. 16 illustrates the various inputs and outputs to the device, which is designed to be mounted in the dashboard of a motor vehicle in the same manner as a conventional radio. Fig. 17 shows the faceplate of this device.

In conclusion, it may be seen that the collision avoidance system according to the present invention is an on-board electronic device which warns the motor vehicle driver, as well as drivers of nearby vehicles, whenever the danger of collision reaches an intolerable level.

The warning to the own motor vehicle driver is in the form of audible sounds (beeps or synthesized voice messages) and a visual display (e.g. of alphanumeric characters). The warning to drivers of other vehicles is by way of the motor vehicle hazard lights and a transmitted signal (beep tones, synthesized voice and/or coded message). The device also switches off the cruise control if the own motor vehicle is in danger of collision with a vehicle ahead.

There has thus been shown and described a novel collision avoidance system for a motor vehicle which fulfills all the objects and advantages sought therefor. Many changes, modifications, variations and other uses and applications of the subject invention will, however, become apparent to those

a second motor vehicle, which is either ahead or behind the given vehicle, with a prescribed threshold (either manually set or chosen automatically).

Figs. 16 and 17 illustrate an actual implementation of the collision avoidance system according to the present invention. In this case, Fig. 16 illustrates the various inputs and outputs to the device, which is designed to be mounted in the dashboard of a motor vehicle in the same manner as a conventional radio. Fig. 17 shows the faceplate of this device.

In conclusion, it may be seen that the collision avoidance system according to the present invention is an on-board electronic device which warns the motor vehicle driver, as well as drivers of nearby vehicles, whenever the danger of collision reaches an intolerable level.

The warning to the own motor vehicle driver is in the form of audible sounds (beeps or synthesized voice messages) and a visual display (e.g. of alphanumeric characters). The warning to drivers of other vehicles is by way of the motor vehicle hazard lights and a transmitted signal (beep tones, synthesized voice and/or coded message). The device also switches off the cruise control if the own motor vehicle is in danger of collision with a vehicle ahead.

It will be appreciated that the preferred embodiments of the present invention are subject to many changes, modifications and variations. All such changes, modifications and variations which may occur to those skilled in the art are intended to be covered by the following claims.

CLAIMS

What is claimed is:

1. Apparatus for controlling a tail light of a motor vehicle, said apparatus comprising, in combination:

(a) a source of voltage;

(b) switch means for selectively connecting said voltage source with said tail light; and

(c) control means, coupled to said switch means, for automatically closing said switch means, thereby connecting said tail light with said voltage source, after the speed of said vehicle falls below a prescribed speed threshold for a prescribed period of time.

2. The apparatus defined in claim 1, further comprising a flasher switch connected in series with said switch means, said flasher switch causing said tail light to flash on and off at a substantially constant rate when said switch means is closed.

3. The apparatus defined in claim 1, wherein said control means is operative to close and open said switch means at a prescribed rate, thereby to cause said tail light to flash on and off after the speed of said vehicle falls below a prescribed threshold for a prescribed period of time.

4. The apparatus defined in claim 3, wherein said prescribed rate is variable.

5. The apparatus defined in claim 1, wherein said prescribed speed threshold is in the range of 0-40 MPH.

6. The apparatus defined in claim 1, wherein said prescribed period of time is in the range of 0-60 seconds.

7. The apparatus defined in claim 1, wherein said control means is operative to close said switch means in response to the simultaneous occurrence of a plurality of conditions, one of which is that the speed of the vehicle falls below a prescribed speed threshold for a prescribed period of time.

8. The apparatus defined in claim 1, wherein said control means is operative to close said switch means, after the speed of said vehicle falls below a prescribed threshold speed for a prescribed period of time, only upon the simultaneous occurrence of the further condition that an engine temperature of the motor vehicle exceeds a prescribed temperature threshold.

9. The apparatus defined in claim 1, wherein said control means is operative to close said switch means, after the speed of the vehicle falls below a prescribed speed threshold for a prescribed period of time, only upon the simultaneous occurrence of the further condition that a prescribed length of time has elapsed since the vehicle ignition switch has been turned on.

10. The apparatus defined in claim 1, further comprising means permitting manual adjustment of said prescribed speed threshold.

11. The apparatus defined in claim 1, further comprising means permitting manual adjustment of said prescribed period of time.

12. The apparatus defined in claim 1, wherein said speed is the instantaneous speed of said vehicle.

13. The apparatus defined in claim 1, wherein said speed is the time average speed of said vehicle.

14. The apparatus defined in claim 1, further comprising means for transmitting a warning signal on an RF carrier, and wherein said control means further includes means for activating said transmitting means after the speed of said vehicle falls below a prescribed speed threshold for a prescribed period of time.

15. Apparatus for controlling the tail light of a motor vehicle, said apparatus comprising, in combination:

(a) a source of voltage;

(b) switch means for selectively connecting said voltage source with said tail light; and

(c) control means, coupled to said switch means, for closing said switch means, thereby connecting said tail light with said voltage source, after the instantaneous speed of said vehicle falls below a prescribed threshold value from the time average speed of said vehicle for a prescribed period of time.

16. The apparatus defined in claim 15, further comprising means for transmitting a warning signal on an RF carrier, and wherein said control means further includes means for activating said transmitting means after the instantaneous speed of said vehicle falls below a prescribed threshold value from the time average speed of said vehicle for a prescribed period of time.

17. Apparatus for controlling the tail light of a first motor vehicle, said apparatus comprising, in combination:

(a) a source of voltage;

(b) switch means for selectively connecting said voltage source with said tail light;

(c) means for determining the difference in speed between said first vehicle and a second motor vehicle that is approaching said first vehicle from one of the front and rear thereof and that is proceeding in substantially the same direction as said first vehicle; and

(d) control means, coupled to said switch means and to said speed difference determining means, for closing said switch means, thereby connecting said tail light with said voltage source, after said speed difference exceeds a prescribed threshold.

18. The apparatus defined in claim 17, further comprising means for determining the distance between said first vehicle and said second vehicle, and wherein said control means varies said prescribed threshold in dependence upon said distance.

19. The apparatus defined in claim 17, further comprising means for determining the speed of said first vehicle, and wherein said control means varies said prescribed threshold in dependence upon said first vehicle speed.

20. Apparatus for controlling the tail light of a first motor vehicle, said apparatus comprising, in combination:

(a) a source of voltage;

(b) switch means for selectivly connecting said voltage source with said tail light;

(c) means for determining the distance between said first vehicle and a second motor vehicle that is one of ahead and behind said first vehicle and is proceeding in substantially the same direction as said first vehicle; and

(d) control means, coupled to said switch means and to said distance determining means, for closing said switch means, thereby connecting said tail light with said voltage source, after said distance falls below a prescribed threshold.

21. The apparatus defined in claim 20, further comprising means for determining the speed of said first vehicle, and wherein said control means varies said prescribed threshold in dependence upon said first vehicle speed.

22. Apparatus for controlling the tail light of a motor vehicle, said vehicle having a plurality of road wheels which rotate at substantially the same speed when said vehicle is in normal operation, said apparatus comprising, in combination:

(a) a source of voltage;

(b) switch means for selectively connecting said voltage source with said tail light;

(c) means for determining when a road wheel of said vehicle is not rotating at substantially the same speed as one or more other road wheels thereof; and

(d) control means, coupled to said switch means and to said determining means, for closing said switch means, thereby connecting said tail light with said voltage source, when a road wheel of said vehicle is not rotating at substantially the same speed as one or more other road wheels thereof.

23. The apparatus defined in claim 22, wherein said determining means compares the rotational speed of a front road wheel of said vehicle with the rotational speed of a rear road wheel thereof.

24. Apparatus for controlling the tail light of a motor vehicle, said apparatus comprising, in combination:

(a) a source of voltage;

(b) switch means for selectively connecting said voltage source with said tail light; and

(c) control means, coupled to said switch means, for automatically closing said switch means, thereby connecting said tail light with said voltage source, when said vehicle is mechanically disabled.

25. In apparatus for automatically controlling the tail light of a motor vehicle comprising switch means for selectively connecting the tail light with a source of voltage and control means for automatically closing said switch means, thereby connecting said tail light to the voltage source, in response to a condition indicating a hazard to other vehicles in the vicinity, the improvement wherein said control means comprises means for sensing the driving environment of said motor vehicle and for changing the condition of response in dependence upon the sensed environment.

26. The improvement defined in claim 25, wherein said condition of response includes the the fall of the instantaneous speed of the vehicle below a prescribed threshold speed for a prescribed period of time.

27. The improvement defined in claim 25, wherein said condition of response includes the fall of the average speed of the vehicle below a prescribed threshold speed for a prescribed period of time.

28. The improvement defined in claim 26, wherein said changing means includes means for changing said threshold speed in dependence upon the driving environment.

29. The improvement defined in claim 26, wherein said changing means includes means for changing said period of time in dependence upon said driving environment.

30. The improvement defined in claim 27, wherein said changing means includes means for changing said threshold speed in dependence upon said driving environment.

31. The improvement defined in claim 27, wherein said changing means includes means for changing said period of time in dependence upon said driving environment.

32. The improvement defined in claim 25, wherein said condition of response includes the fall of the instantaneous speed of the vehicle below a prescribed threshold value from the time average speed of said vehicle for a prescribed period of time.

33. The improvement defined in claim 25, wherein said condition of response includes the increase of the speed difference between the own vehicle and a second motor vehicle that is approaching the own vehicle from one of the front and the rear thereof, while travelling in substantially in the same direction as the own vehicle, above a prescribed threshold.

34. The improvement defined in claim 25, wherein said condition of response includes the fall of the distance between the own vehicle and a second motor vehicle that is one of ahead and behind the own vehicle and travelling in substantially the same direction as the own vehicle, below a prescribed threshold.

35. Apparatus for controlling the hazard warning system of a motor vehicle, said apparatus comprising, in combination:

(a) a source of voltage;

(b) switch means for connecting said voltage source with said hazard warning system; and

(c) control means, coupled to said switch means, for automatically closing said switch means, thereby activating said hazard warning system, when said vehicle is being operated by an unauthorized driver.

36. The apparatus defined in claim 35, wherein said hazard warning system comprises at least one tail light.

37. The apparatus defined in claim 35, wherein said hazard warning system comprises an RF transmitter.

38. The apparatus defined in claim 35, wherein said motor vehicle further comprises a burglar alarm system, and wherein said control means is responsive to the activation of said burglar alarm system to close said switch means.

39. The apparatus defined in claim 35, wherein said motor vehicle further comprises an ignition key switch, and wherein said control means is responsive to the operation of the motor vehicle engine without activation of said ignition key switch to close said switch means.

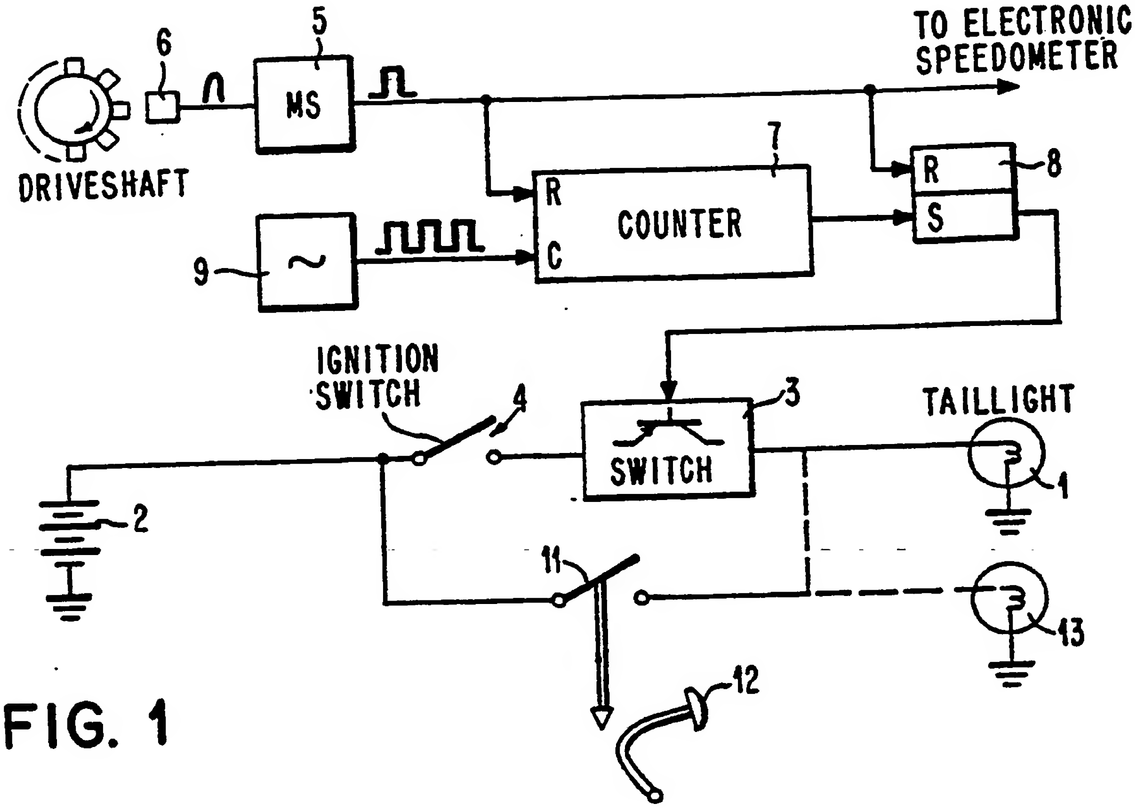


FIG. 1

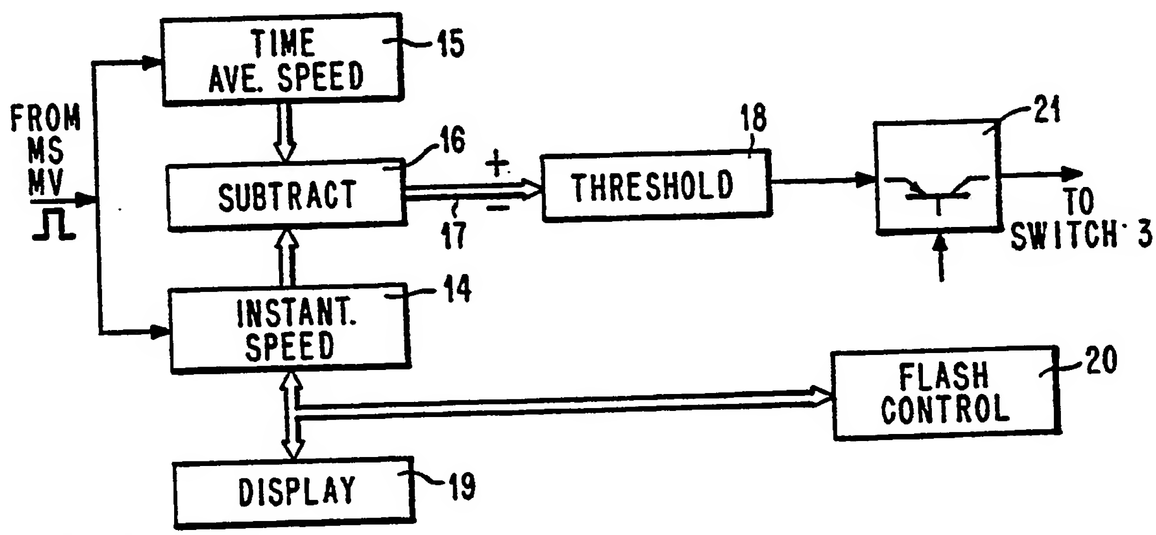


FIG. 2

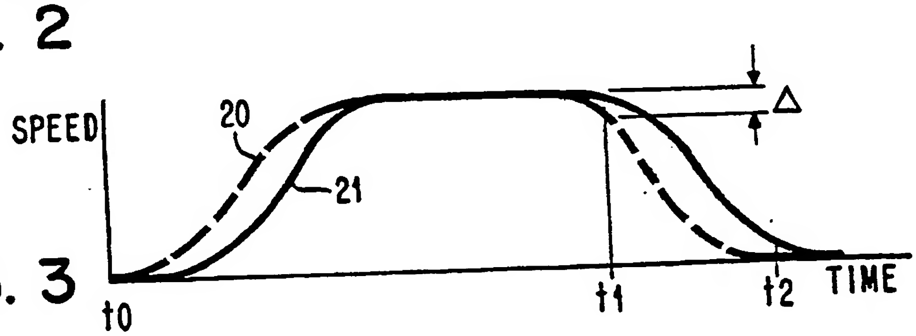


FIG. 3

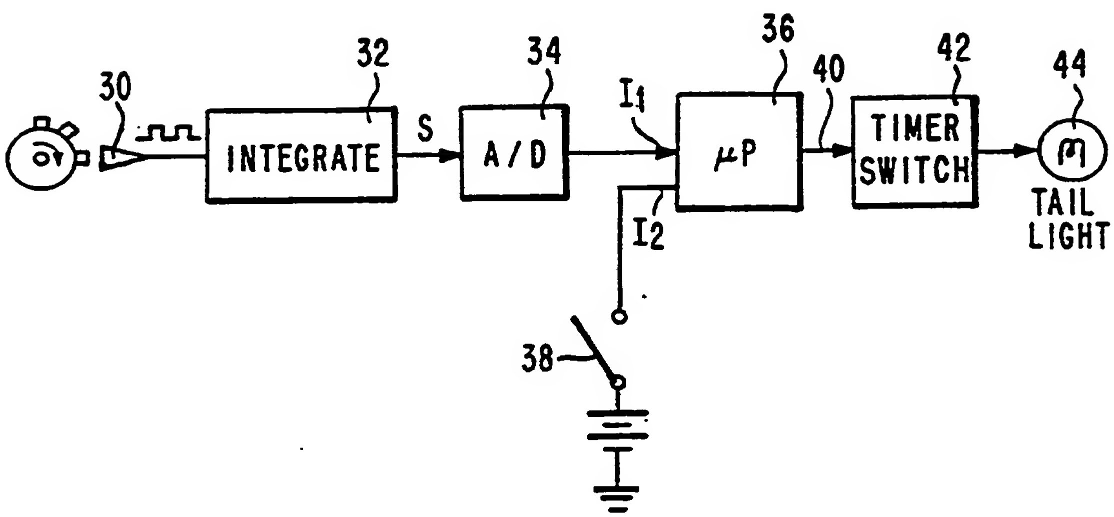

30
32
INTEGRATE
S
34
A / D
I_1
36
μP
40
42
TIMER SWITCH
44
TAIL LIGHT
I_2
38

FIG. 4

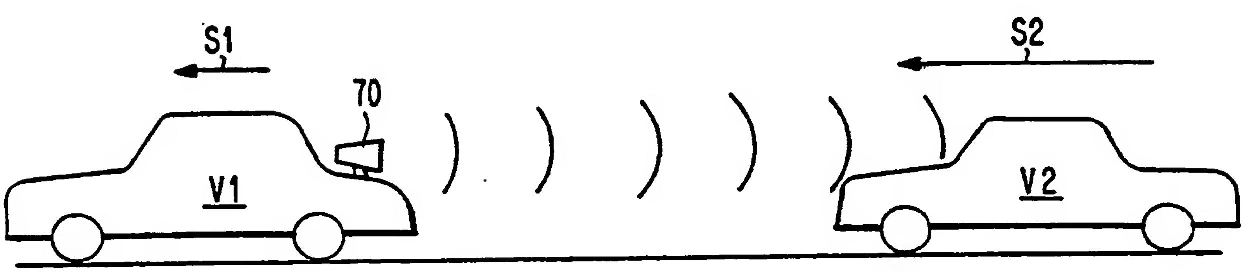

S1
70
V1
S2
V2

FIG. 6

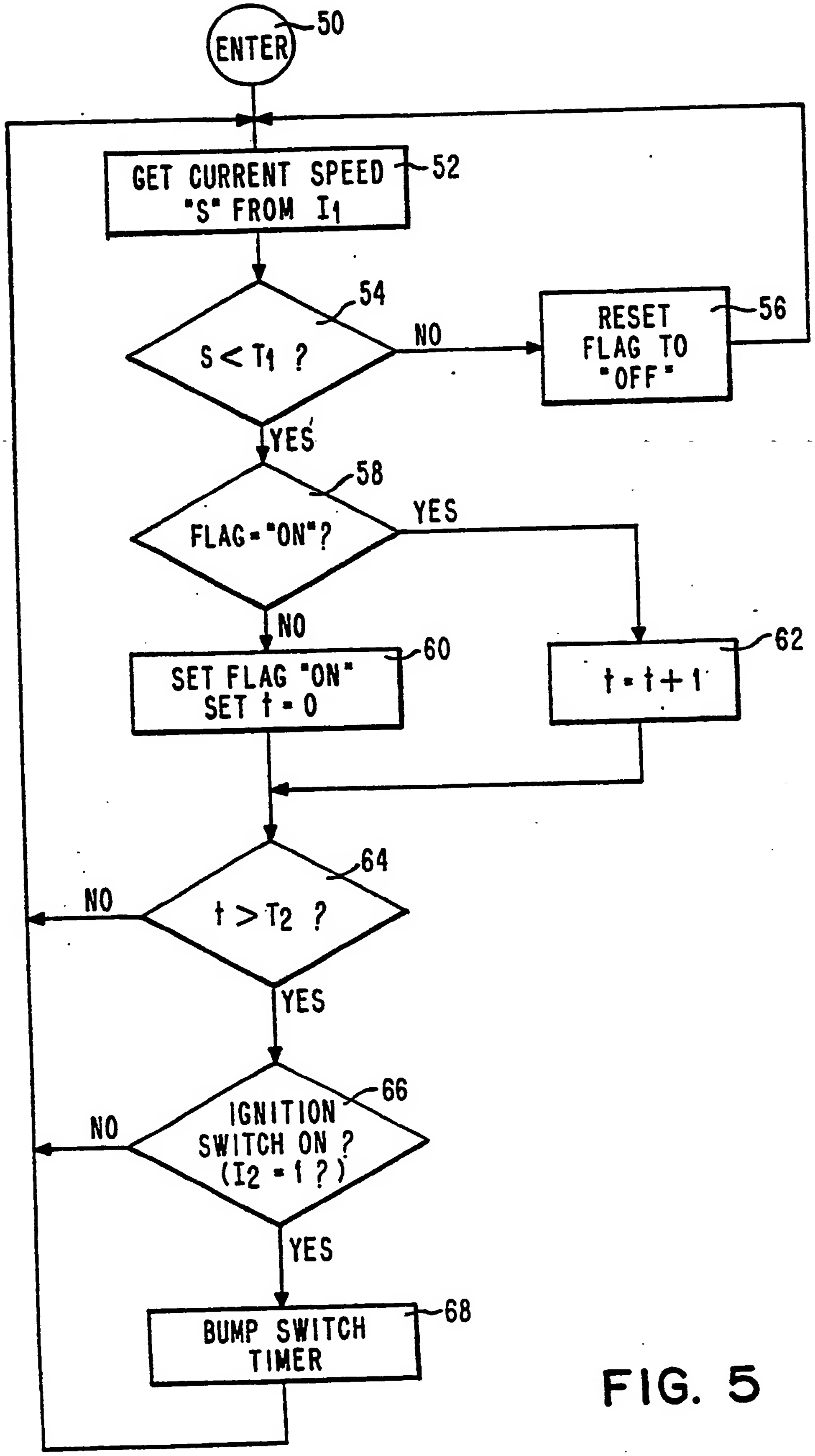

ENTER
50
GET CURRENT SPEED "S" FROM I_1
52
$S < T_1$?
54
NO
RESET FLAG TO "OFF"
56
YES
FLAG = "ON"?
58
YES
NO
SET FLAG "ON" SET t = 0
60
t = t + 1
62
t > T_2 ?
64
NO
YES
IGNITION SWITCH ON ? (I_2 = 1 ?)
66
NO
YES
BUMP SWITCH TIMER
68

FIG. 5

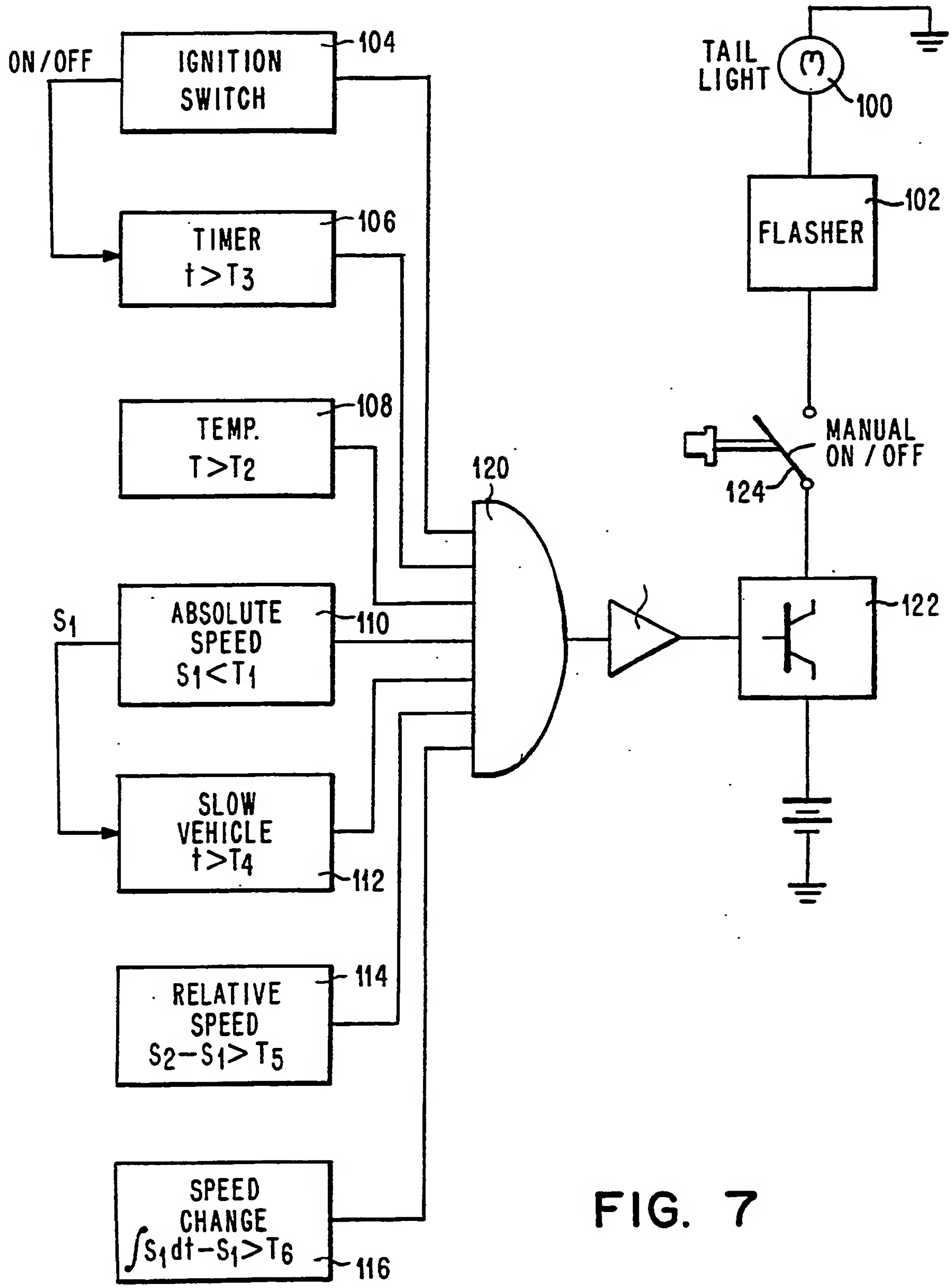

ON/OFF
IGNITION SWITCH
104
TIMER
$t>T_3$
106
TEMP.
$T>T_2$
108
S_1
ABSOLUTE SPEED
$S_1<T_1$
110
SLOW VEHICLE
$t>T_4$
112
RELATIVE SPEED
$S_2-S_1>T_5$
114
SPEED CHANGE
$\int S_1dt-S_1>T_6$
116
120
TAIL LIGHT
100
FLASHER
102
MANUAL ON / OFF
124
122

FIG. 7

FIG.8

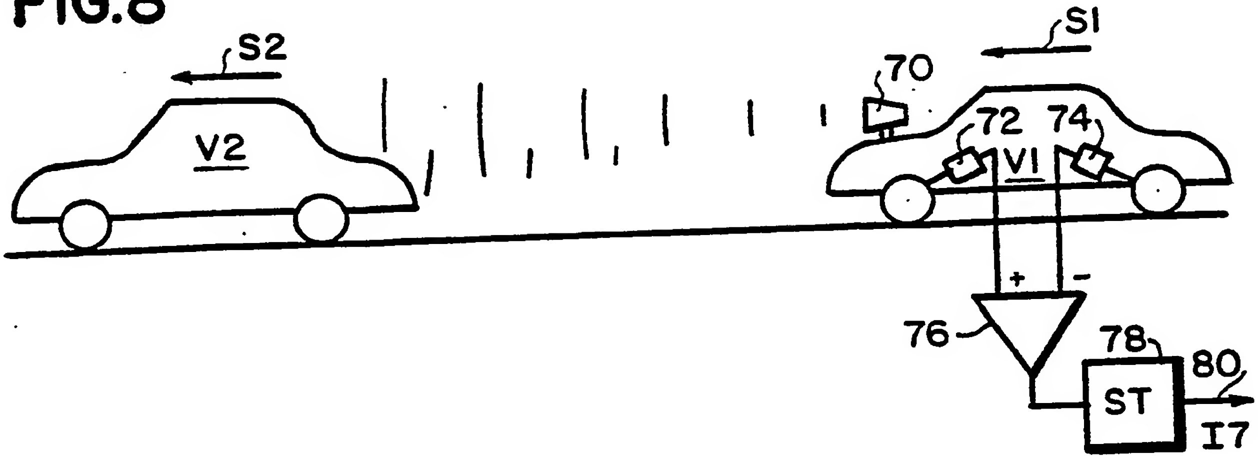


FIG.9

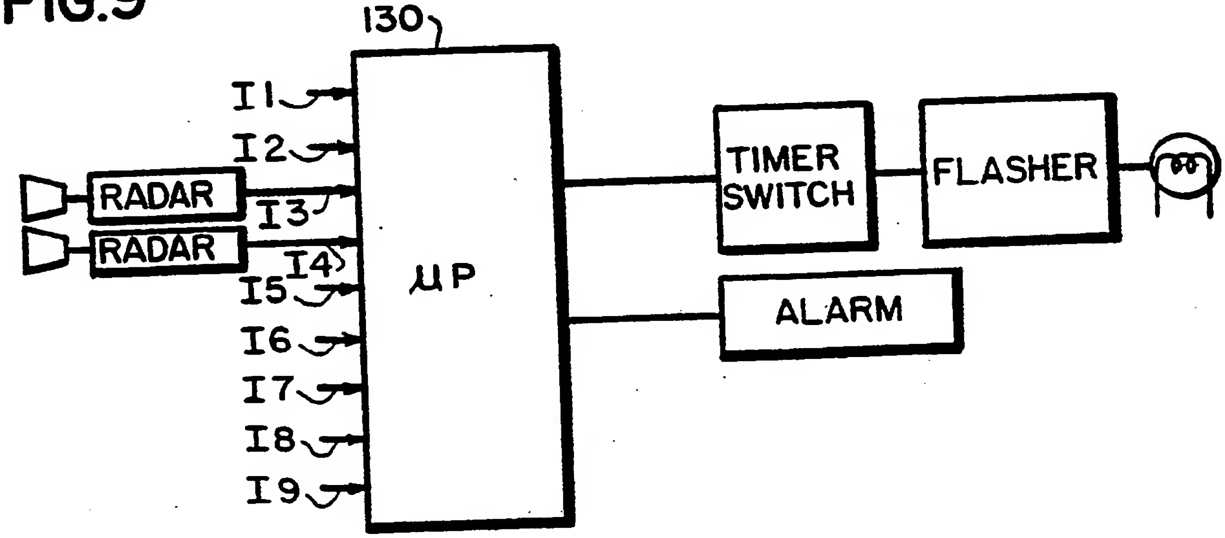
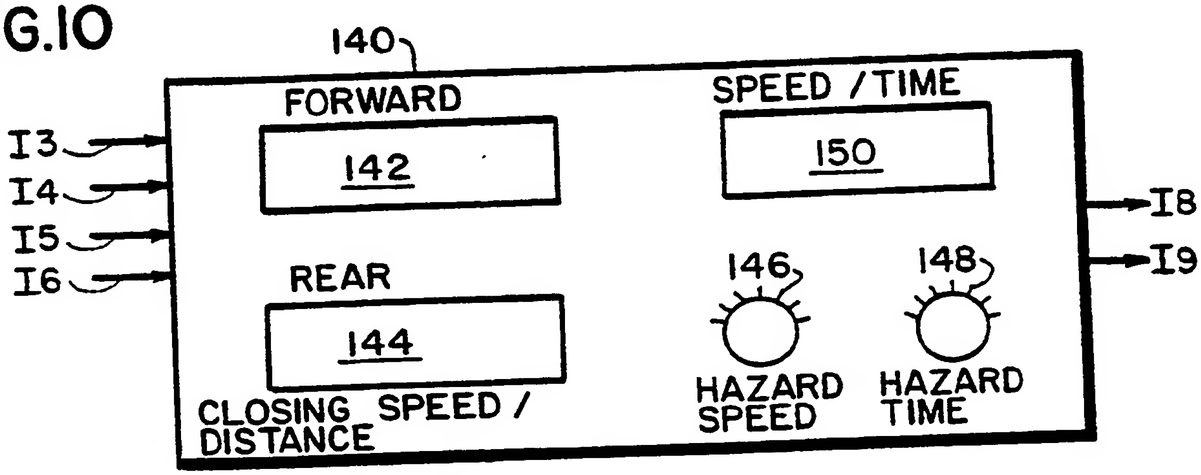


FIG.10



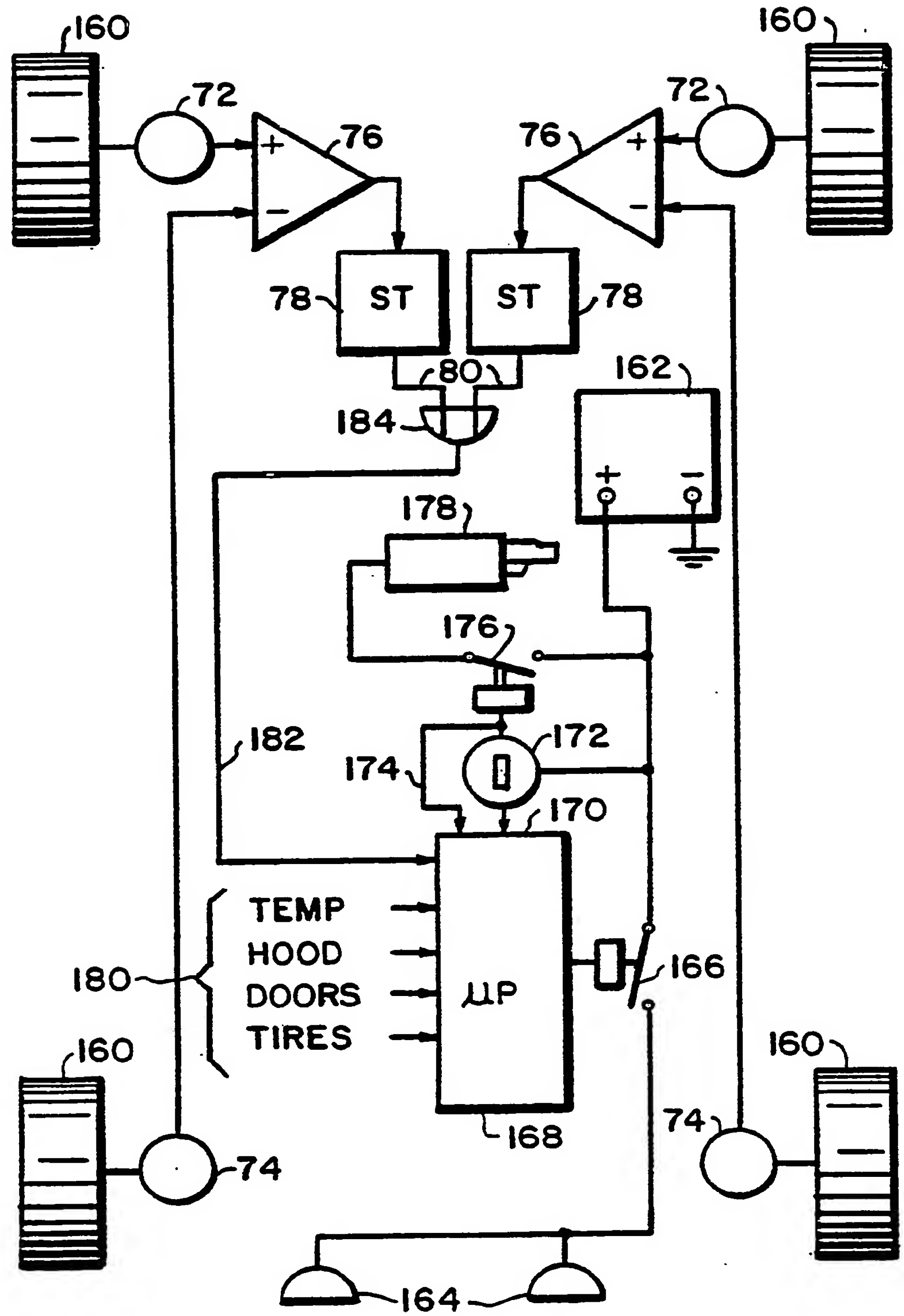

160
160
72
72
76
76
ST
ST
78
78
80
184
162
+
−
178
176
182
172
174
170
TEMP
HOOD
DOORS
TIRES
180
µP
166
160
160
168
74
74
164

FIG.11

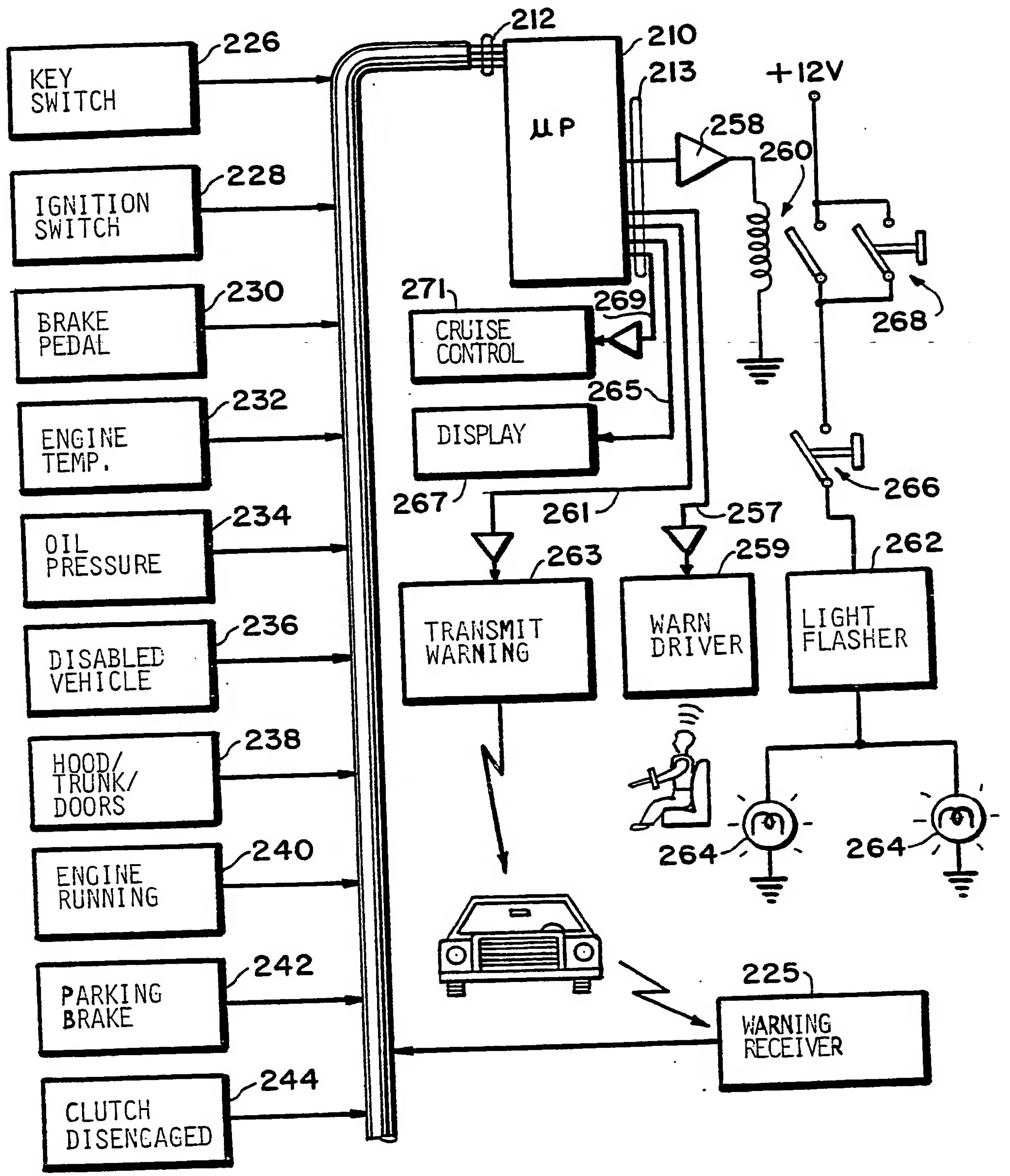
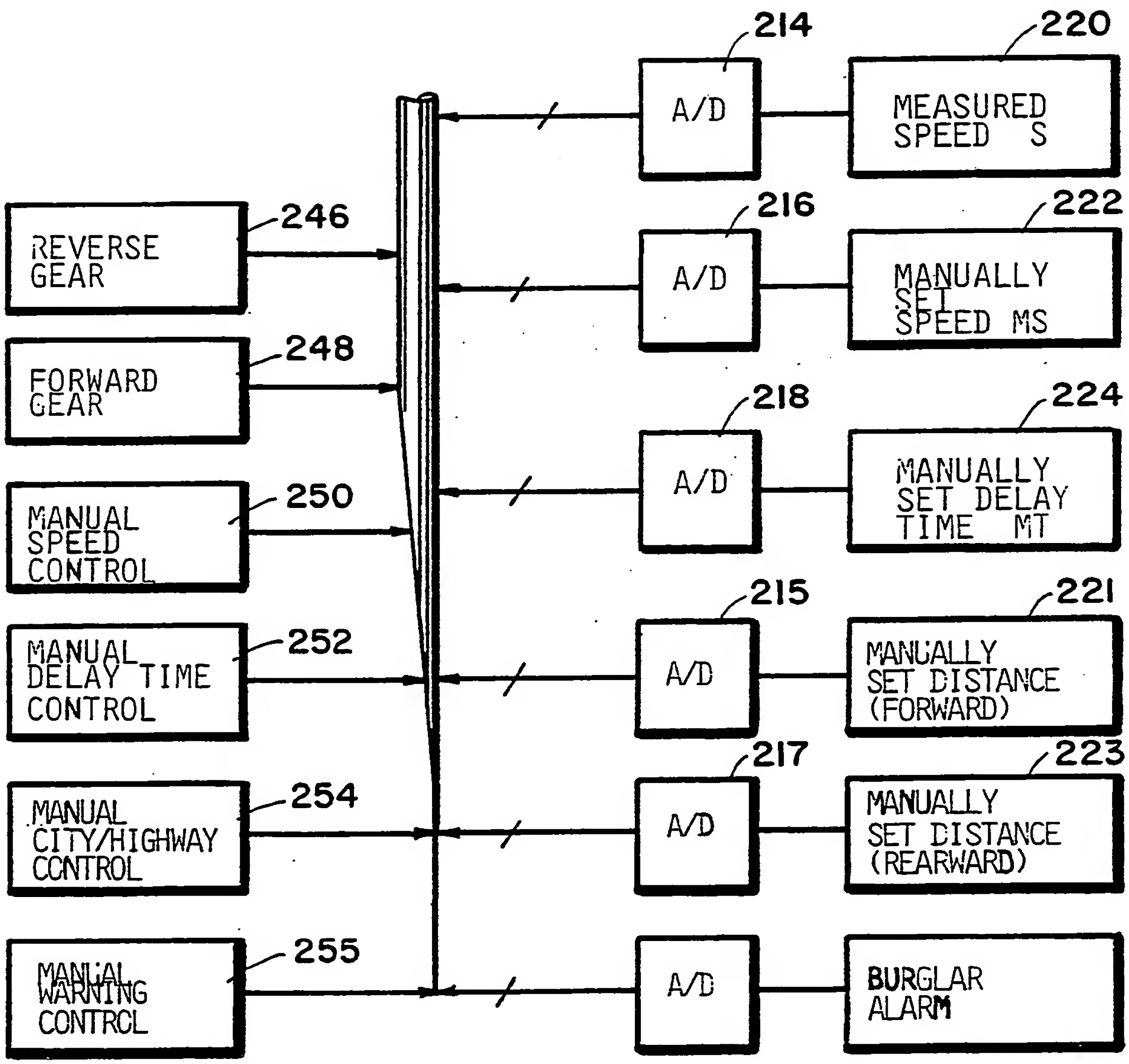
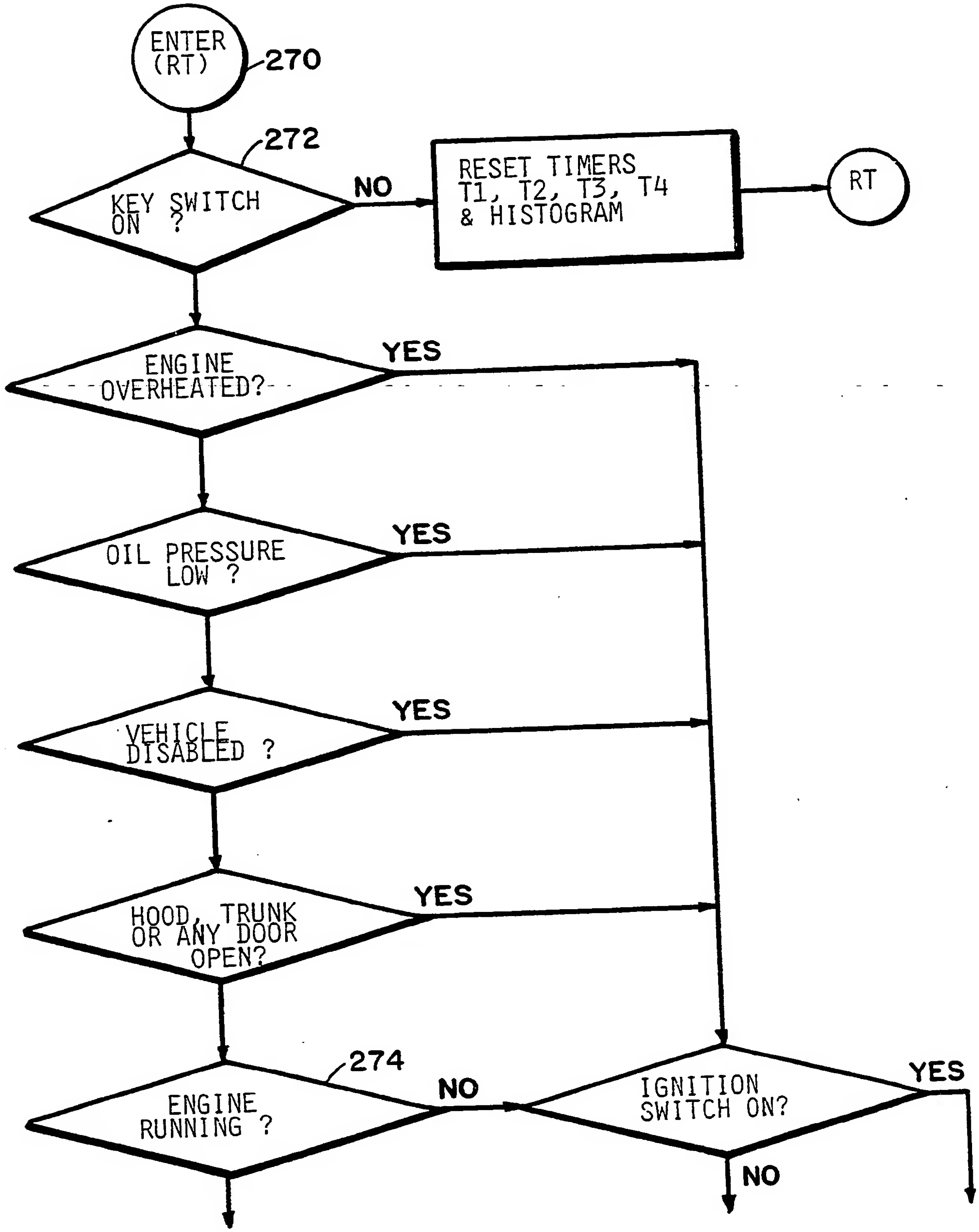

KEY SWITCH
226
IGNITION SWITCH
228
BRAKE PEDAL
230
ENGINE TEMP.
232
OIL PRESSURE
234
DISABLED VEHICLE
236
HOOD/ TRUNK/ DOORS
238
ENGINE RUNNING
240
PARKING BRAKE
242
CLUTCH DISENGAGED
244
212
210
213
µP
+12V
258
260
271
269
CRUISE CONTROL
268
265
DISPLAY
266
267
261
257
263
259
262
TRANSMIT WARNING
WARN DRIVER
LIGHT FLASHER
264
264
225
WARNING RECEIVER

FIG.12A

FIG.12B


REVERSE GEAR
246
FORWARD GEAR
248
MANUAL SPEED CONTROL
250
MANUAL DELAY TIME CONTROL
252
MANUAL CITY/HIGHWAY CONTROL
254
MANUAL WARNING CONTROL
255
A/D
214
MEASURED SPEED S
220
A/D
216
MANUALLY SET SPEED MS
222
A/D
218
MANUALLY SET DELAY TIME MT
224
A/D
215
MANUALLY SET DISTANCE (FORWARD)
221
A/D
217
MANUALLY SET DISTANCE (REARWARD)
223
A/D
BURGLAR ALARM



ENTER (RT)
270
272
KEY SWITCH ON ?
NO
RESET TIMERS T1, T2, T3, T4 & HISTOGRAM
RT
ENGINE OVERHEATED?
YES
OIL PRESSURE LOW ?
YES
VEHICLE DISABLED ?
YES
HOOD, TRUNK OR ANY DOOR OPEN?
YES
274
ENGINE RUNNING ?
NO
IGNITION SWITCH ON?
YES
NO

FIG.13A

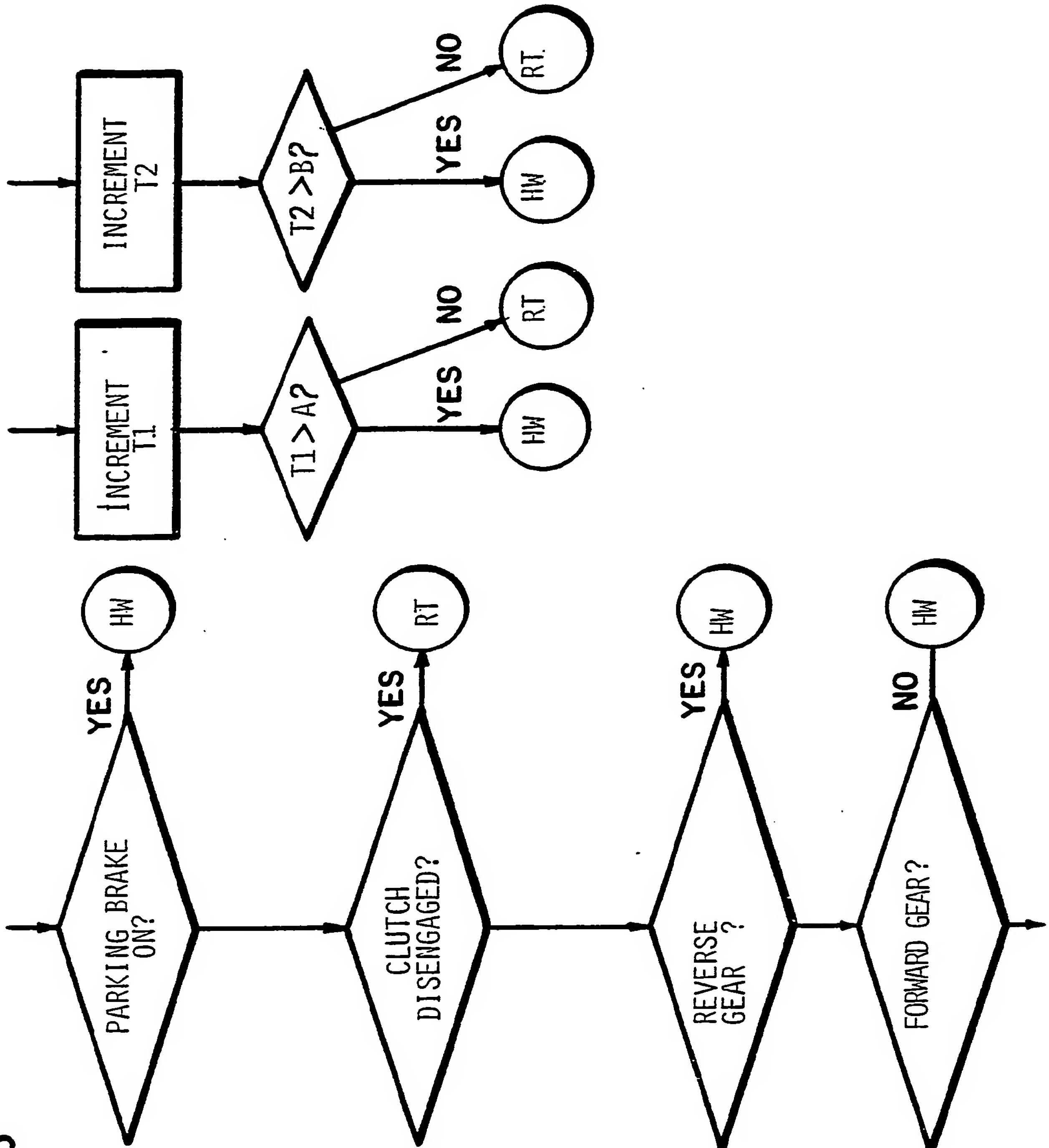

INCREMENT T2
T2 > B?
YES
NO
HW
RT.
INCREMENT T1
T1 > A?
YES
NO
HW
RT
PARKING BRAKE ON?
YES
HW
CLUTCH DISENGAGED?
YES
RT
REVERSE GEAR ?
YES
HW
FORWARD GEAR ?
NO
HW

FIG.13B

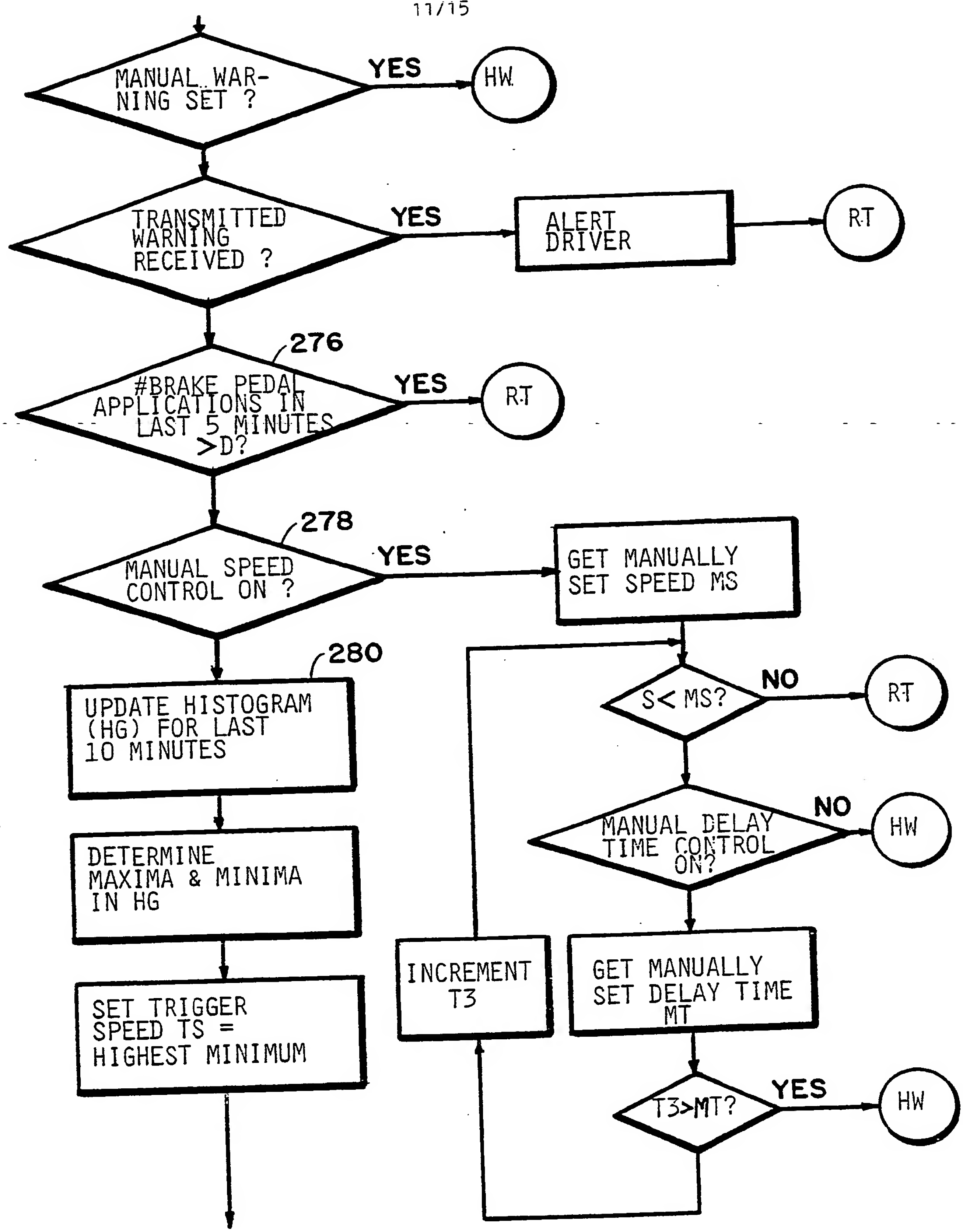

MANUAL WARNING SET ?
YES
HW
TRANSMITTED WARNING RECEIVED ?
YES
ALERT DRIVER
RT
276
#BRAKE PEDAL APPLICATIONS IN LAST 5 MINUTES >D?
YES
RT
278
MANUAL SPEED CONTROL ON ?
YES
GET MANUALLY SET SPEED MS
280
UPDATE HISTOGRAM (HG) FOR LAST 10 MINUTES
S< MS?
NO
RT
DETERMINE MAXIMA & MINIMA IN HG
MANUAL DELAY TIME CONTROL ON?
NO
HW
INCREMENT T3
GET MANUALLY SET DELAY TIME MT
SET TRIGGER SPEED TS = HIGHEST MINIMUM
T3>MT?
YES
HW

FIG.13C

FIG.13D

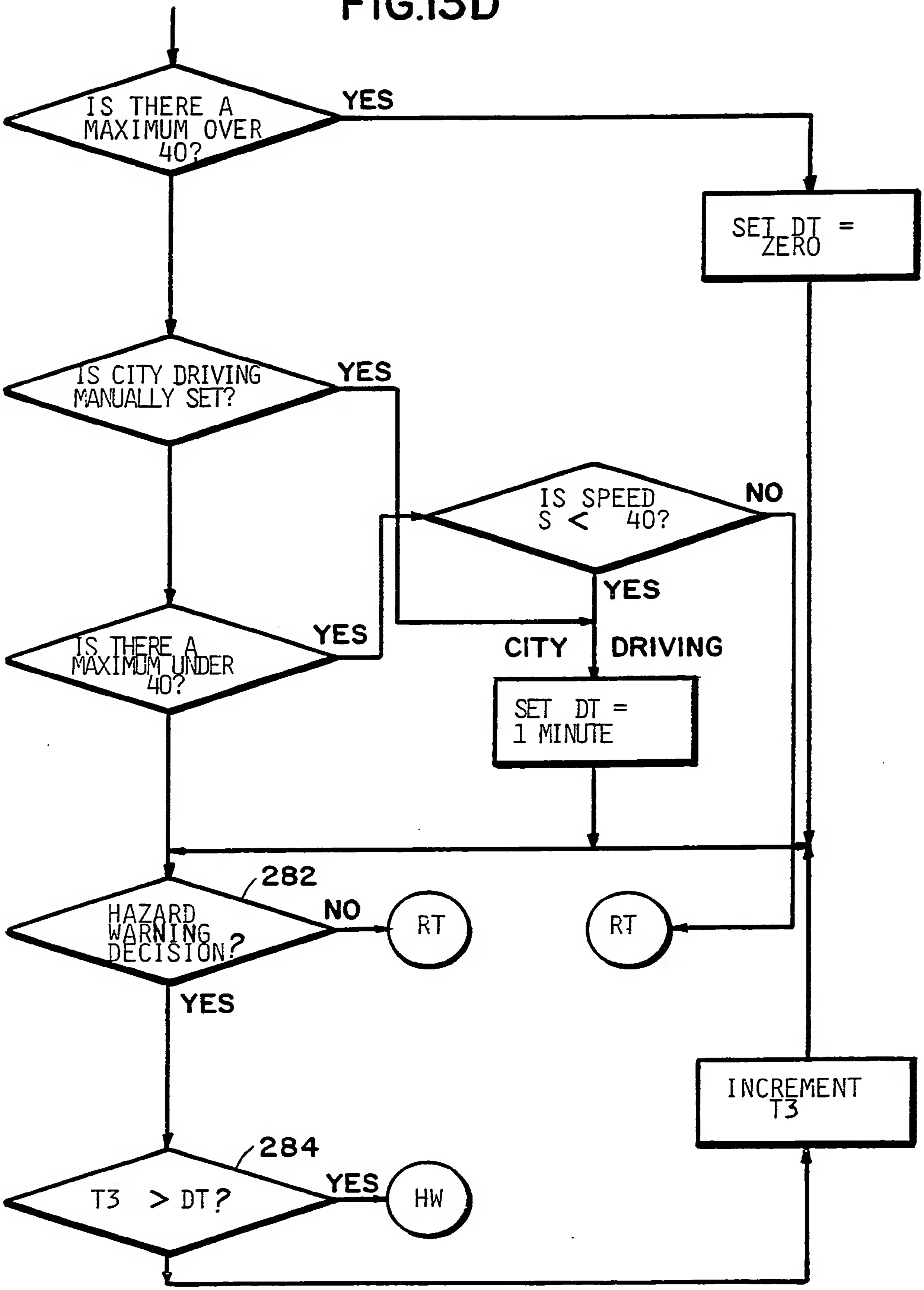

IS THERE A MAXIMUM OVER 40?
YES
SET DT = ZERO
IS CITY DRIVING MANUALLY SET?
YES
IS SPEED S < 40?
NO
YES
CITY DRIVING
IS THERE A MAXIMUM UNDER 40?
YES
SET DT = 1 MINUTE
282
HAZARD WARNING DECISION?
NO
RT
RT
YES
INCREMENT T3
284
T3 > DT?
YES
HW

FIG.14

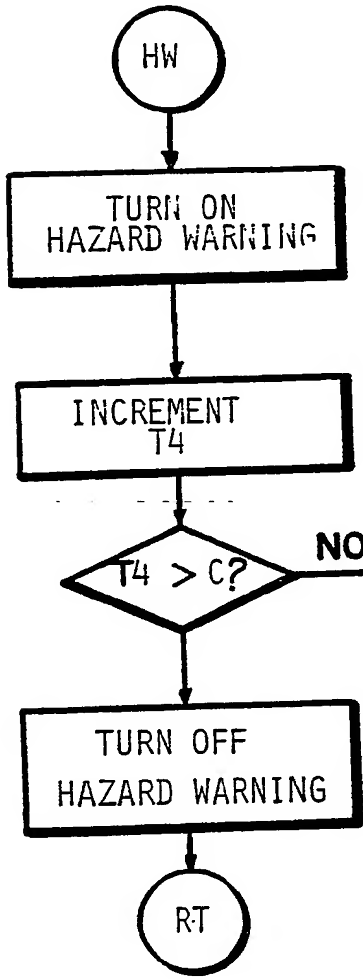
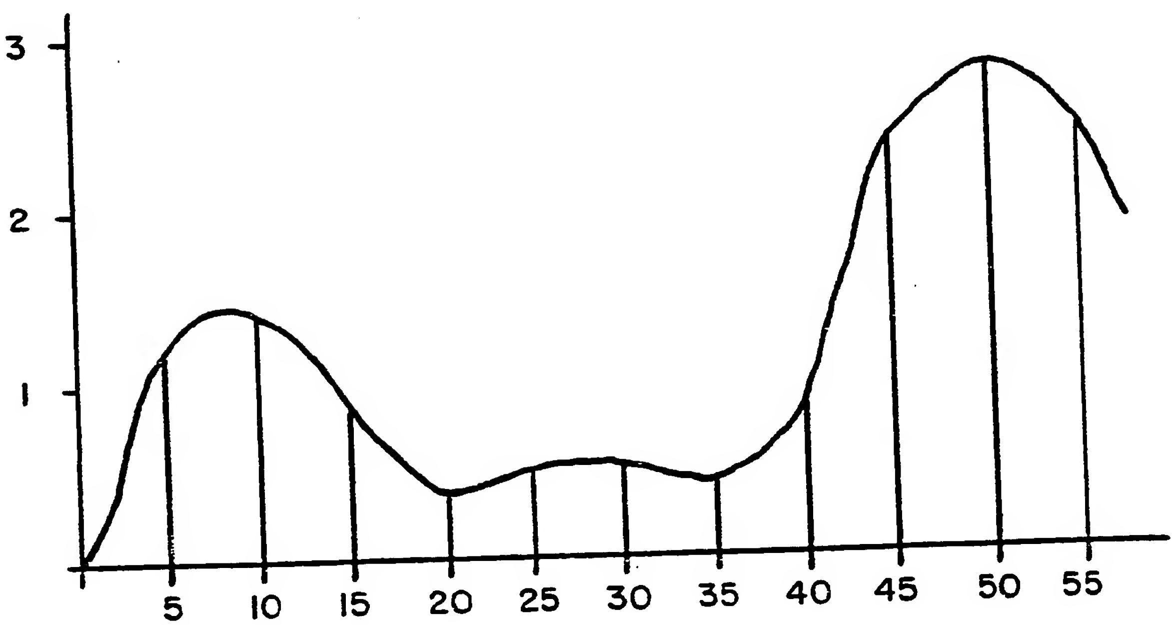

HW
TURN ON HAZARD WARNING
INCREMENT T4
T4 > C?
NO
RT
TURN OFF HAZARD WARNING
RT

FIG.15


3
2
1
5
10
15
20
25
30
35
40
45
50
55

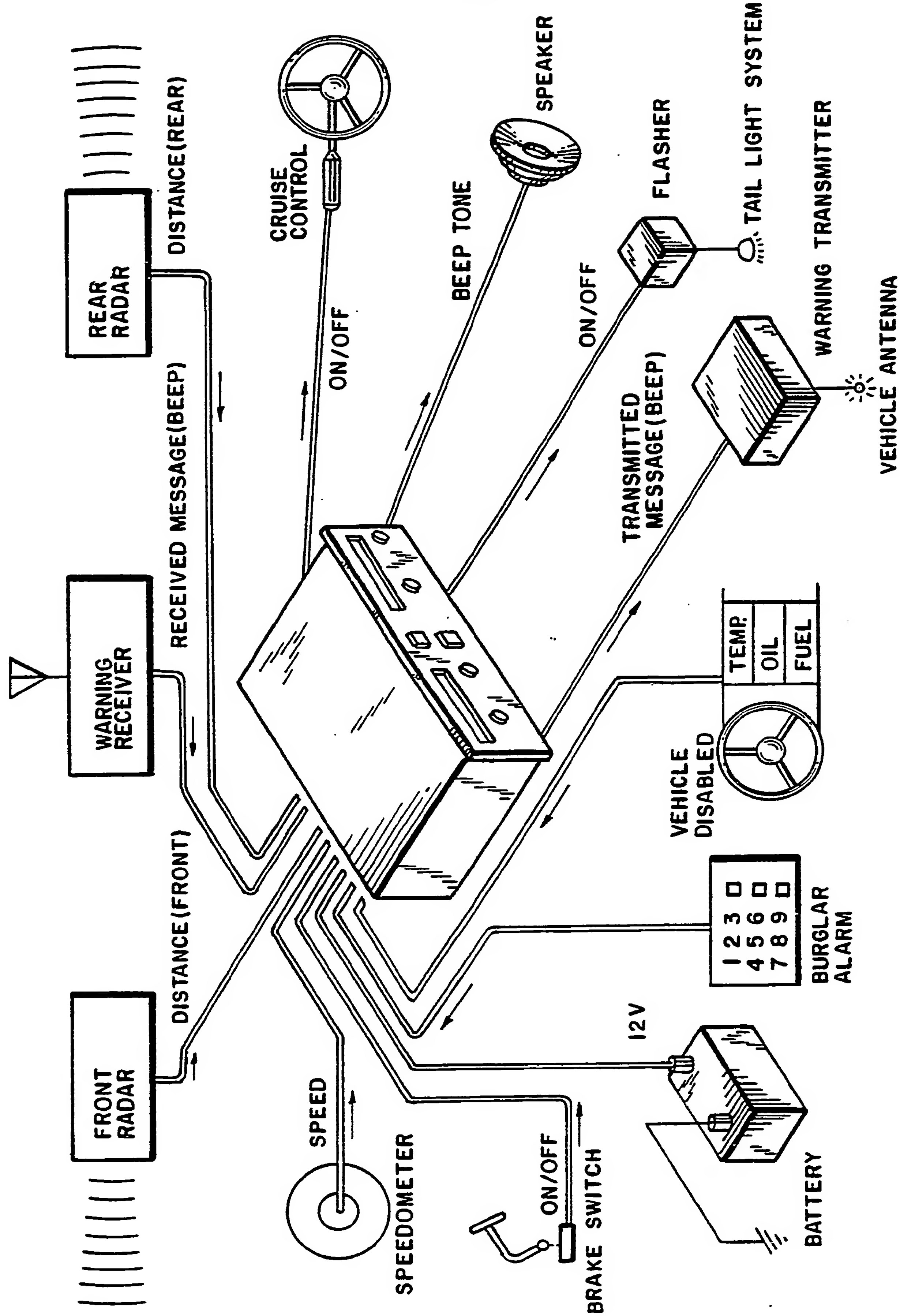

REAR RADAR
DISTANCE(REAR)
CRUISE CONTROL
ON/OFF
SPEAKER
BEEP TONE
FLASHER
ON/OFF
TAIL LIGHT SYSTEM
WARNING TRANSMITTER
VEHICLE ANTENNA
TRANSMITTED MESSAGE(BEEP)
WARNING RECEIVER
RECEIVED MESSAGE(BEEP)
TEMP.
OIL
FUEL
VEHICLE DISABLED
FRONT RADAR
DISTANCE(FRONT)
1 2 3
4 5 6
7 8 9
BURGLAR ALARM
12V
SPEED
SPEEDOMETER
ON/OFF
BRAKE SWITCH
BATTERY

FIG.16

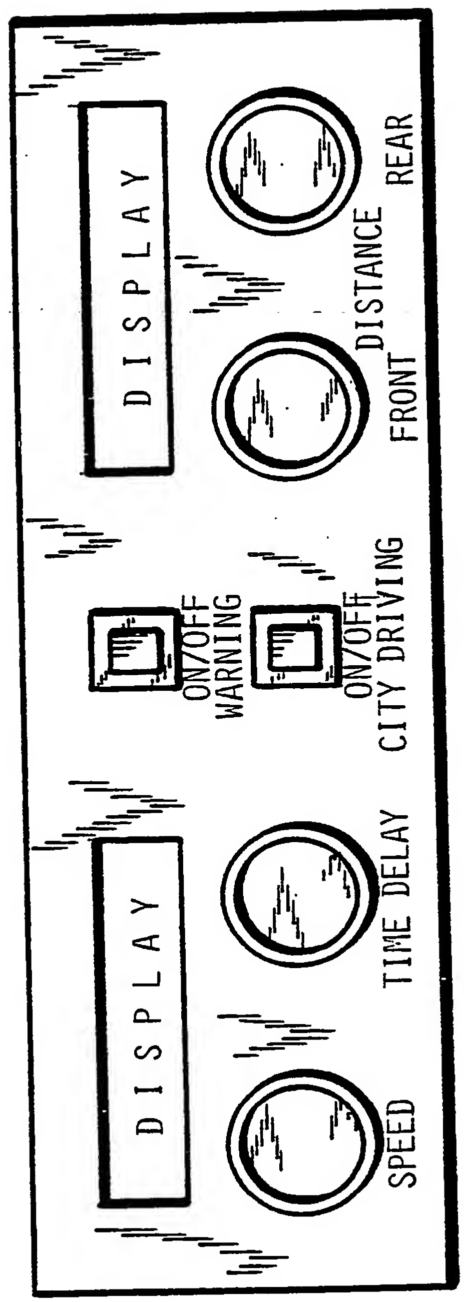

DISPLAY
DISPLAY
SPEED
TIME DELAY
ON/OFF
WARNING
ON/OFF
CITY DRIVING
FRONT
DISTANCE
REAR

FIG.17

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US88/00669

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL.[4] B60Q 1/26, G08G 1/00, B60Q 1/44,
U.S. CL. 340/62,72

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	340/62, 340/904, 340/903, 340/72, 340/64

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A, 4,357,594 (Ehrlich et al), 02 November 1982, See column 13, lines 27 to 57, column 6, line 4.	1-13,15,25-34, 22,23
Y,P	US, A, 4,706,086 (Panizza), 10 November 1987, See column 3, lines 27 to 64.	14,16
Y	DE, A, 2,714,434 (Mitsubishi), 20 October 1977, See the English Abstract on cover sheet.	17-21
Y	US, A, 4,346,365 (Ingram), 24 August 1982, See column 3, lines 54 to 56.	24
Y	US, A, 4,673,914 (Lee), 16 June 1987, See column 2, lines 35 to 41.	35-39

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
25 APRIL 1988	17 JUN 1988
International Searching Authority	**Signature of Authorized Officer**
ISA/US	Annie H. Chau Annie H. Chau

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